



IBM

Field Engineering

Theory of Operation

Restricted Distribution

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2311 **Disk Storage Drive**
Models 1, 11, and 12



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PREFACE

This IBM Field Engineering Theory of Operation Manual includes descriptions of the mechanics and hydraulics as well as the circuit logic of the 2311. Circuitry involving control of the format of the data written on the disks is described in the Field Engineering Theory of Operation Manual of the using system.

The differences between the basic model 1 and the models 11 and 12 are covered in the text. The special circuits needed to convert from one to the other are explained.

It is assumed that the reader has completed training on and understands the IBM System/360 Model 20 or larger, and the IBM 2841 and/or Model 20 SCU feature.

The FE Maintenance Manual, IBM 2311 Disk Storage Drive, Models 1, 11, and 12, Form Y26-5923, provides information on the maintenance of the 2311. Other related manuals are:

FE Theory of Operation, IBM 2841 Storage Control, Stage 2, Form Y26-4000

FE Theory of Operation, System/360 Model 20 Storage Control Feature, Form Y33-1000

FE Diagram Manual, Storage Control Feature, System/360 Model 20, Form Y33-1007

Systems Reference Library, IBM System/360 Component Descriptions, etc., Form A26-5988

Systems Reference Library, IBM System/360 Model 20 Functional Characteristics, Form A26-5847

Systems Reference Library, IBM Disk Pack Handling and Operating Procedures, Form A26-5756

The abbreviation SCU in this text refers to either the IBM 2841 Storage Control or the IBM System/360 Model 20 storage control feature.

Fifth Edition

This manual (Y26-5897-4) is a major revision of the previous version.

Specifications contained herein are subject to change from time to time. Any such change will be reported in subsequent revisions or Field Engineering Supplements.

The illustrations in this manual have a code number in the lower corner. This is a publishing control number and is not related to the subject matter.

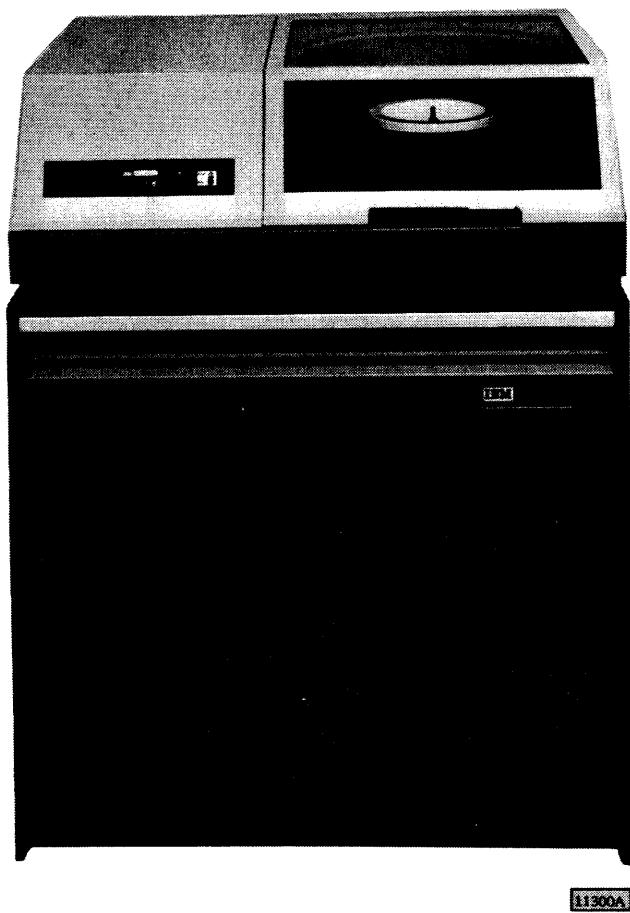
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ABBREVIATIONS

CAR	cylinder address register	SCU	Used interchangeably in this manual to refer to the IBM 2841 Storage Control (Unit), or the storage control feature on the IBM System/360 Model 20.
HAR	head address register	SS	Singleshot
kHz	kilohertz (kilocycles/sec)	STCL	storage control - model 20
MHz	megahertz (megacycles/sec)		



IBM 2311 Disk Storage Drive

BASIC OPERATING CHARACTERISTICS

The IBM 2311 Disk Storage Drive provides the rotational drive, read/write circuitry, and access mechanism needed to write on and read from the IBM 1316 Disk Pack.

A disk pack provides storage for up to 7.25 million 8-bit bytes on ten recording surfaces. The disk packs are interchangeable, thus providing access to large amounts of data.

The 2311 operates as a slave to its control device. There are two control devices: the IBM 2841 Storage Control, which attaches to a channel on the IBM System/360 Model 30 or larger; and the Storage Control Feature (native attachment), which is part of the IBM System/360 Model 20. For simplicity's sake, references that apply equally to both control devices will be abbreviated to SCU.

When controlled by an IBM 2841, the 2311 model 1 is used. When attached to the System/360 Model 20, the 2311 models 11 or 12 are used (Figure 1-1).

The central processing unit (CPU) sends commands to the SCU, which interprets and uses the commands to control the functions of the 2311.

The 2311 performs three functions: seek, read, and write. Although there are many commands used in conjunction with the 2311, each command basically causes the 2311 to perform one or more of these three functions.

To be able to read from or write on the disk surface, some mechanism must position the read/write (R/W) heads at the area containing the desired information. This mechanism is called the access mechanism and has three major components:

1. The hydraulic actuator furnishes back-and-forth movement to the carriage assembly.
2. The carriage assembly places and holds the ten R/W heads in operating position.
3. The detent assembly holds the carriage at the desired position.

The movable part of the access mechanism is the hydraulically activated carriage assembly containing ten vertically aligned R/W heads. The hydraulic actuator can position the carriage assembly at 203 separate horizontal positions. The disk surface read by one head at one horizontal position of the carriage assembly is called a track. Because all ten R/W heads are vertically aligned and move back and

forth in unison, ten tracks are available for use at one setting. These ten vertically aligned tracks form a cylinder of tracks, or more simply, a cylinder. Therefore, there are 203 available cylinders (of data) on a disk pack. One cylinder (ten tracks) contains a maximum of 36,250 bytes of data

A seek command (from the CPU) causes the carriage assembly to move from one cylinder position to another. The direction and number of cylinders the carriage moves is determined by the SCU. The number of the head (0-9) to be used (on the subsequent read or write command) is included in the seek command, and is stored for future use in the head address register (HAR).

All data transmission to or from the 2311 is serial by bit. The format of the data written on the pack is controlled by the SCU. Additional information on data format can be found under the section titled "Format".

IBM 1316 DISK PACK

- The major components of the disk pack are: the eight disks, hub, clamp rings, spindle-lock mechanism, bottom dust cover, and top dust cover with attached handle (Figure 1-2).
- The eight disks consist of six recording disks, a top protective disk, and the sector disk (bottom protective disk).
- The hub provides vertical and horizontal alignment of the disks when the pack is mounted on the 2311 spindle.
- The clamp rings hold the disks securely to the hub and prevent the disks from shifting horizontally.
- The spindle-lock mechanism holds the disk pack assembly firmly to the 2311 spindle.
- The entire disk pack assembly, when removed from the 2311, is enclosed in dust covers for off line storage.

Figure 1-2 shows the six recording disks separated by five disk supports (spacers). The protective disks are separated from the top and bottom recording disks

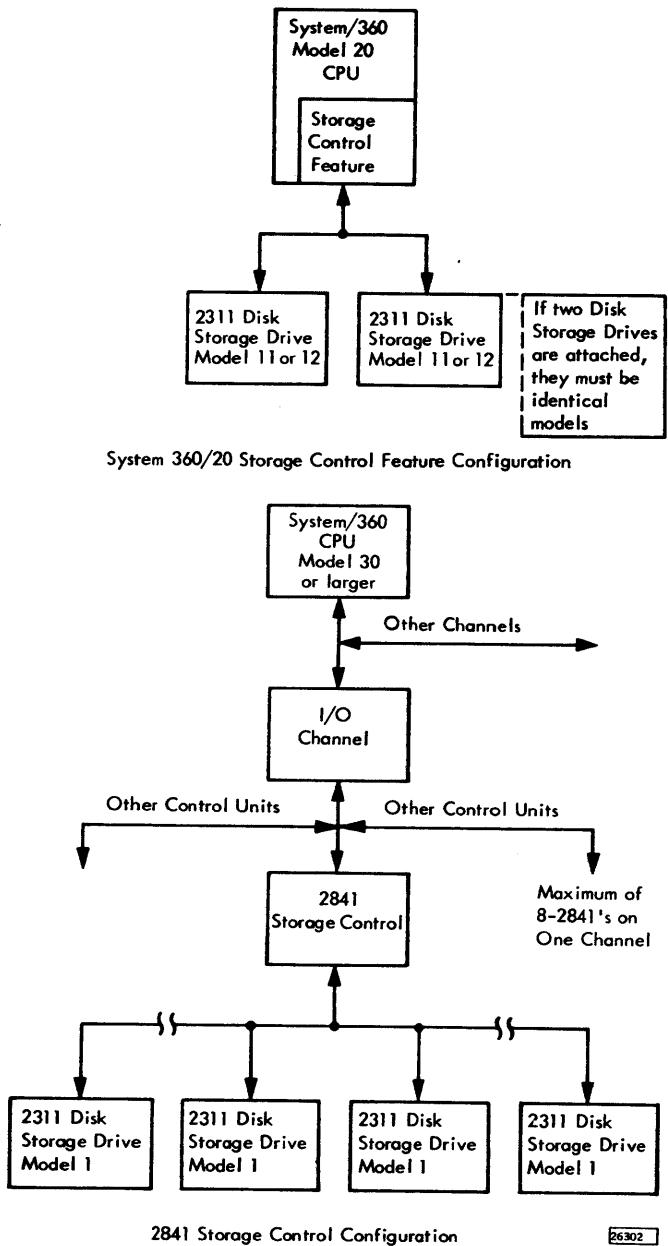


Figure 1-1. System 360/20 and 2841 Storage Control Configuration

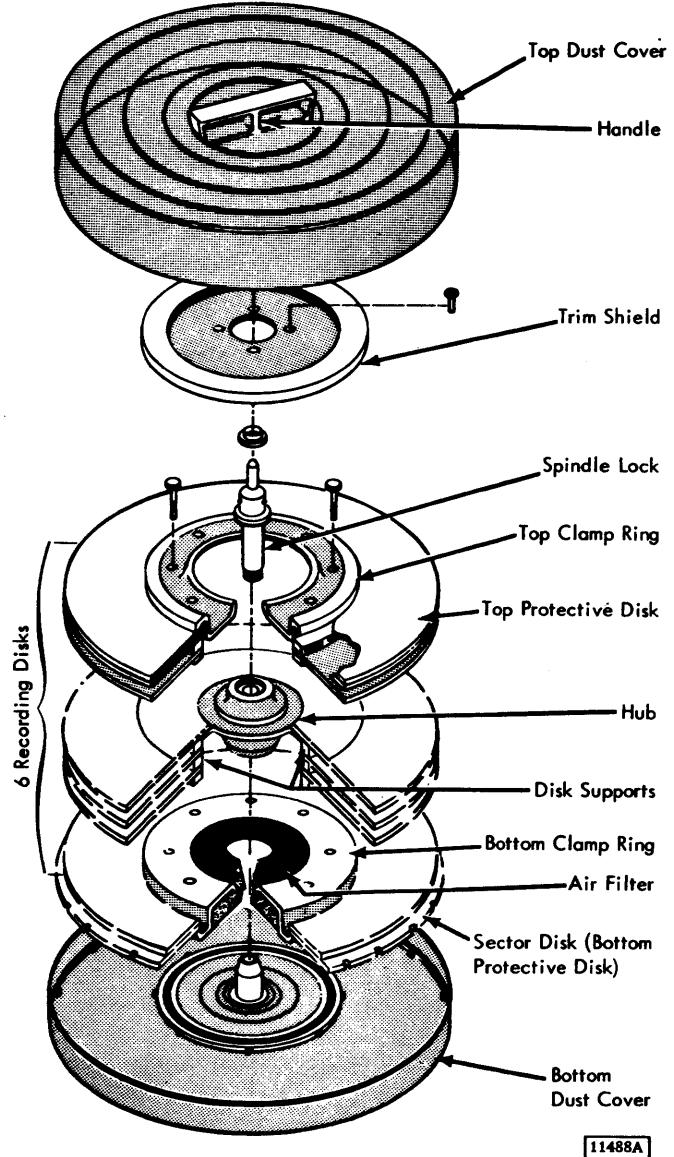


Figure 1-2. Disk Pack Assembly

by thin shims. The thin shims do not leave enough room for R/W heads to go between the protective disk and the recording disk; therefore, only ten disk surfaces are available for use. Figure 1-3 illustrates the proximity of the protective disks.

The disk pack, mounted on a 2311 and ready for use, rotates at 2,400 revolutions per minute (RPM), which is equivalent to one revolution per 25 ms.

The entire disk pack weighs approximately ten pounds.

ACCESS MECHANISM

- The major components of the access mechanism are: the hydraulic actuator, carriage assembly (including R/W head-arm assemblies), and the detent (Figures 1-3, 1-4, and 1-5).
- The access mechanism performs four basic functions: loading, positioning, unloading, and retracting the R/W head/arm assemblies.

Hydraulic Actuator

The hydraulic actuator is a three-speed, bidirectional mechanism which drives the carriage assembly to a specific cylinder. A pump supplies the necessary hydraulic pressure of 200 psi.

The following sequence takes place when the start/stop switch is turned on:

1. The drive motor is energized, supplying power to the hydraulic pump and starting the disk pack.
2. When the hydraulic pressure builds up, the detent arm pulls out of the detent gear. The detent pulling out of the detent gear frees the carriage assembly so it can be moved.
3. The disk pack reaches 70% of rated speed, causing the extend solenoid to be energized (Figure 1-3).
4. The extend solenoid and valve actuate the extend piston, moving the extend piston to its limit of travel (hydraulic home).
5. The extend piston moving to hydraulic home pushes the access piston out an equal amount.
6. The access piston is attached to the carriage assembly via the carriage drive rod. Therefore, the carriage also moves an amount equal to the movement of the extend piston.
7. At this time, the cylinder position indicator is pointing at approximately minus cylinder 1-1/2. The R/W heads are protruding into the disk pack.
8. Also initiated by power-on is a one-minute cleaning cycle. During the one-minute interval, a group of brushes, motor-driven, moves into and out of the disk pack to sweep away any small dust particles that may be adhering to the disk surfaces.

9. After the cleaning cycle is completed, the access piston moves forward (toward the spindle) until the carriage assembly hits a mechanical stop (crash stop).

Note: During the time the carriage assembly is going forward on this initial operation (power-on seek), the head load cam causes the heads to load. Head loading is the process of placing the R/W heads close (125 microinches) to the disk surfaces. The head-loading operation is described fully under the section titled "Head Loading and Unloading."

10. After the crash stop is reached, the access piston reverses motion and returns to hydraulic home.
11. The access piston then moves slowly forward to cylinder position 000 and the detent is re-engaged with the detent gear, locking the carriage assembly firmly in place.
12. The carriage assembly is now in operating position with the heads loaded, and the access ready light (green) on the operator's panel is on.

The access mechanism can now respond to commands issued by the CPU, such as 'recalibrate' or 'seek'. The access piston's movements are controlled by the two speed-control valves and the direction control valve. The access piston controls the movement of the carriage, which is attached to the access piston by the drive rod.

Carriage Assembly

The carriage provides a movable platform on which the R/W heads are mounted, allowing fast, accurate positioning of the heads at a specific cylinder. The major components of the carriage assembly are: movable rack-mounted carriage, ten R/W head/arm assemblies, a receiver, and the head loading mechanism (including torsion rods). The rack-mounted carriage moves on rollers on the carriage housing. A basic part of the movable carriage is the receiver. The receiver holds the R/W head/arm assemblies. The torsion rods are a part of the head loading mechanism and protrude through the receiver. The top and bottom rails of the movable carriage contain racks that drive two pinion gears when the car-

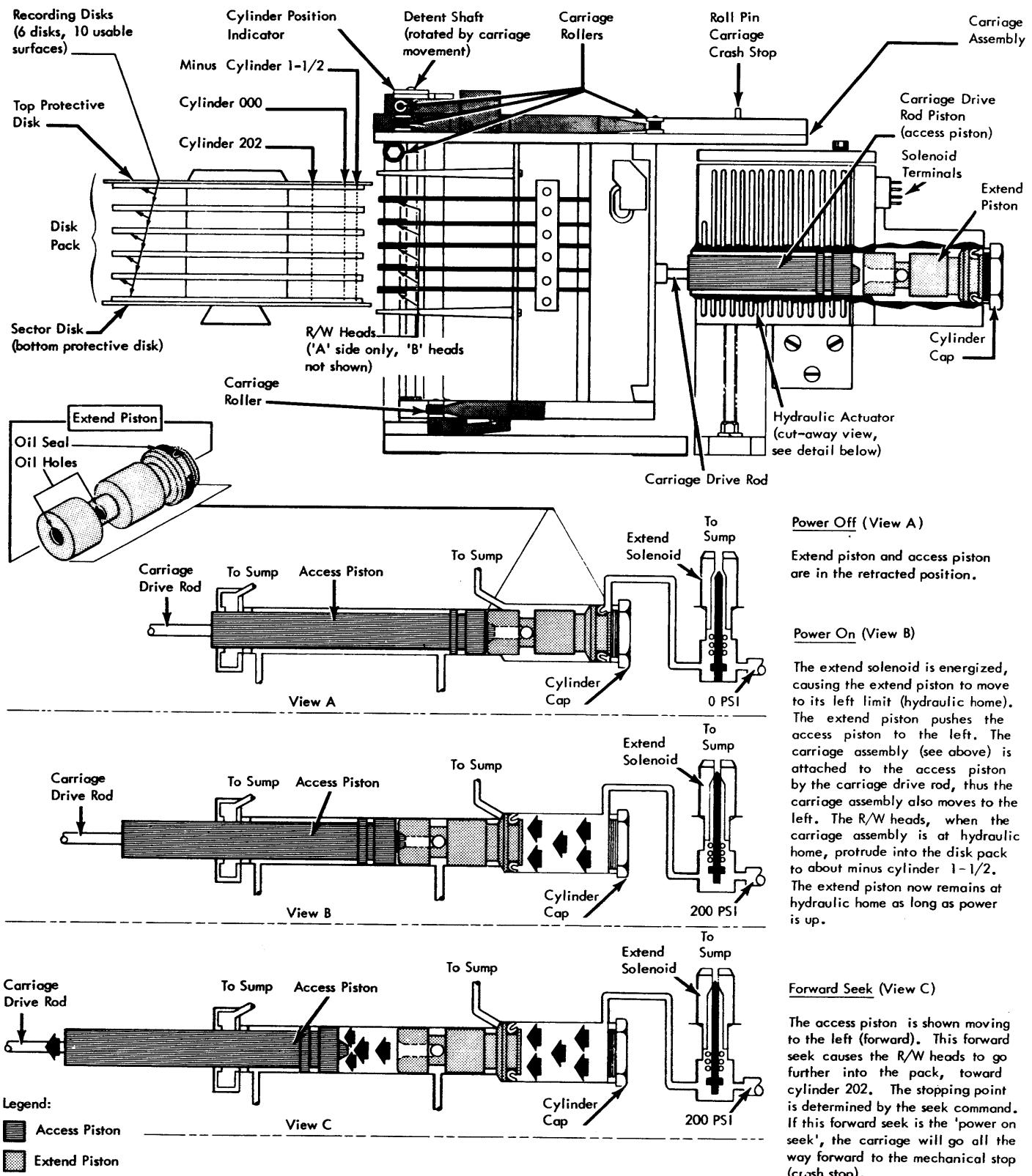
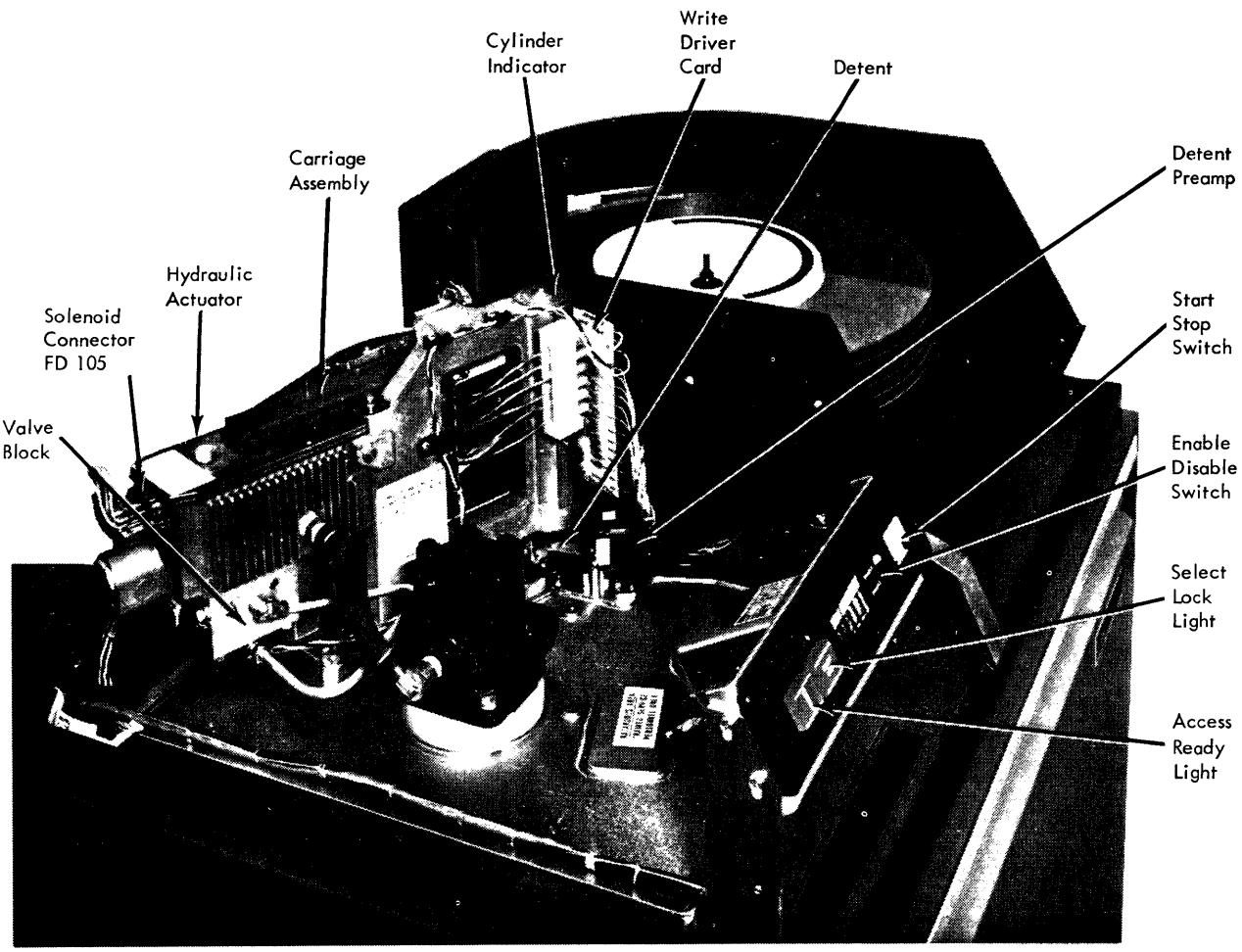


Figure 1-3. 2311 Rear View - Actuator and Carriage



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Figure 1-4. Disk Pack and Access Mechanism

riage is moved back and forth during accessing operations. The pinion gears are attached to a common vertical shaft mounted to the carriage housing. A cylinder slotted disk (track position disk) and detent gear are mounted at the bottom end of the shaft. The cylinder slotted disk, in conjunction with a transducer, counts cylinders. The detent gear and detent mechanism hold the carriage at a specific cylinder position.

Detent

The spring-loaded detent arm holds the carriage at a precise cylinder location while engaged with the detent gear. The detent actuator is energized to move the carriage assembly to another cylinder position. The detent actuator forces the detent arm out of the detent gear, freeing the carriage assembly. When

the movement to another cylinder is completed, the hydraulic pressure on the detent actuator is removed, and the detent is re-engaged with the detent gear under spring pressure.

Head Loading and Unloading (Figure 1-6)

The head load operation occurs during power up on the first forward seek (power-on seek) of the carriage assembly. A head load cam, latched in position by the last previous power-off operation, operates against a cam follower and pushrod. The pushrod rotates the torsion rods in their sockets, pushing against the R/W heads and forcing the heads toward the disk surfaces. The torsion rods are held in the rotated position by a continuously energized latch. The design of the R/W heads is such that they "fly"

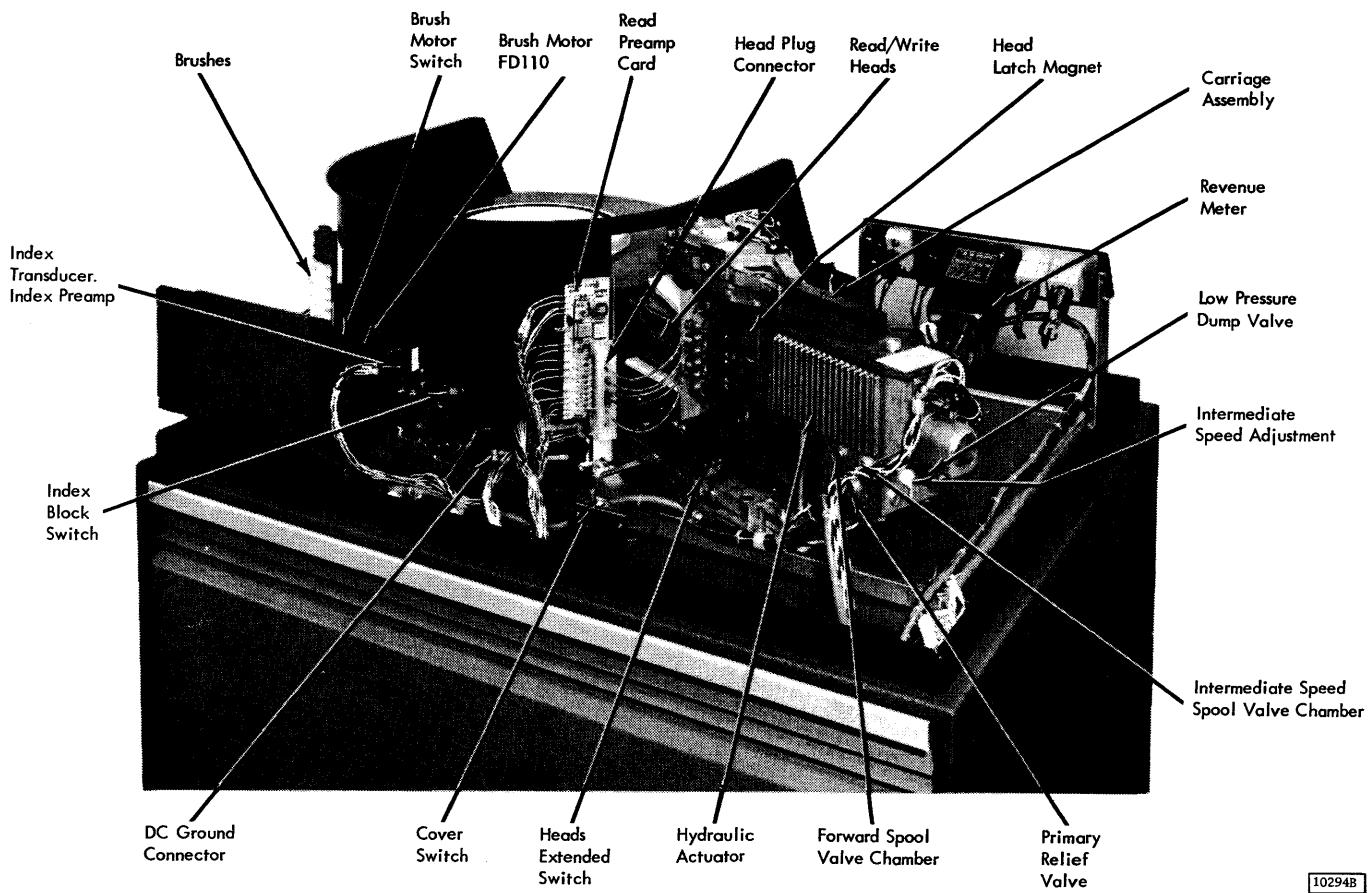


Figure 1-5. Hydraulic Mechanism, Rear View

upon the air dragged along by the rotating disks. The force of the air acting on the heads balances the opposing force of the torsion rods, and the heads maintain a position approximately 125 microinches above the disk surface.

Turning the start/stop switch to the stop position drops the power to the drive motor and simultaneously drops dc power to the head load latch. The heads immediately return to an unloaded condition, the access mechanism retracts to hydraulic home, and the extend piston retracts, pulling the carriage back out of the pack.

The head load cam, which loaded the heads on the initial seek, is unlatched at the end of the first forward movement of the carriage assembly. The cam is not used and remains out of the way as long as the carriage remains between cylinders 000 and 202. When the carriage is completely retracted (power off) the head load cam is relatched, in preparation for the next power-on seek.

DATA ORGANIZATION

- Each 1316 disk pack has ten usable surfaces with 203 tracks per surface.
- A total of 203 cylinders of data are available with three cylinders designated as spares (model 12, 103 cylinders total, three spares).
- Each track has a track error-flagging record which, under program control, permits switching to a spare track if the addressed track is flagged as defective.
- A variable number of records, depending on the length of the records, can be stored on each track (model 1 only).

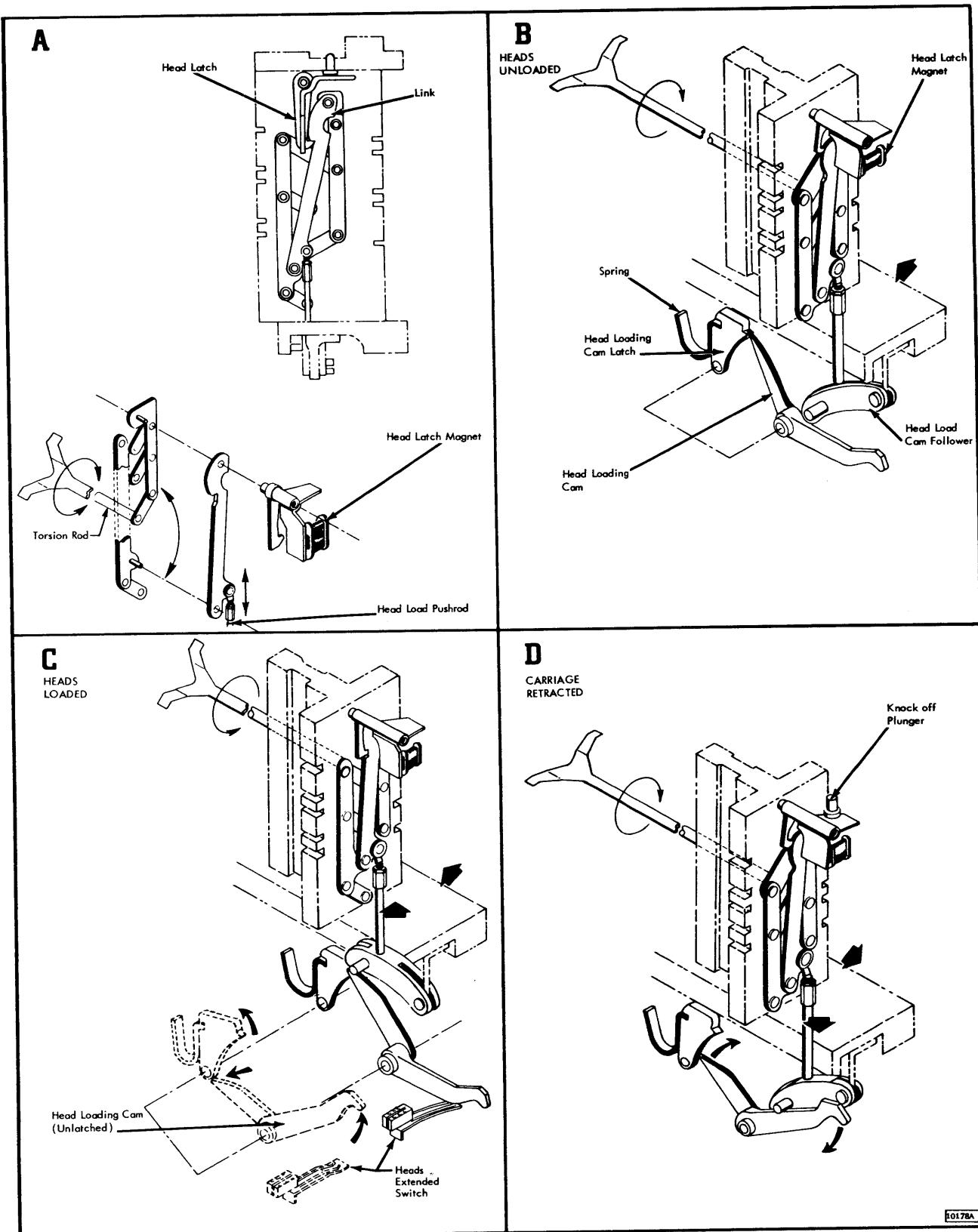


Figure 1-6. Head Load Mechanism

- Because of the variable record lengths, and type of programs used, the total capacity of a disk pack varies up to a maximum of 7.25 million bytes. (model 1 only. See Figure 1-7).
- The model 11 has each track divided into ten sectors, causing a lower storage capacity of 5.4 million bytes (Figure 1-7).
- The model 12 also has ten sectors per track. In addition, the number of available cylinders has been reduced to 103, reducing storage capacity to one-half (2.7 million bytes) that of the model 11 (Figure 1-7).

Access to the data on the disk pack is attained by positioning the R/W head array, mounted on the carriage, to any of 203 (103, model 12) cylinder positions.

At each cylinder position, any one of the ten tracks can be read by selecting the proper head. This vertical alignment of tracks is called a cylinder of tracks or, more simply, a cylinder (Figure 1-8).

A seek operation moves the carriage to one of the available cylinders of data. Head selection then permits reading or writing to take place on a specific track within that cylinder.

The alternate tracks available for use, in the event a normal track must be flagged as defective, depends upon the user's program. When it becomes necessary to write on an alternate track, IBM programming systems for the System/360 Model 30 and larger utilize cylinders 200-202; IBM programming systems for the System/360 Model 20 utilize cylinders 001-003.

	2311 Model 1	2311 Model 11	2311 Model 12
Storage Capacity	7.25 Million Bytes	5.4 Million Bytes	2.7 Million Bytes
Data Transfer Rate	156,000 Bytes/Sec	156,000 Bytes/Sec	156,000 Bytes/Sec
Data Bytes/Sector	-	270 Bytes	270 Bytes
Sectors/Track	-	10	10
Data Bytes/Track	3,625 Bytes	2,700 Bytes	2,700 Bytes
Number of Disk Pack Surfaces	10	10	10
Data Bytes/Cylinder	36,250 Bytes	27,000 Bytes	27,000 Bytes
Data Cylinders	200	200	100
Alternate Cylinders	3	3	3
Maximum Access Time	135 ms	135 ms	90 ms
Average Access Time	75 ms	75 ms	60 ms
Minimum Access Time	25 ms	25 ms	25 ms
Disk Rotation Time	25 ms	25 ms	25 ms
<p>Note: Capacity quoted for Model 1 in this chart assumes that IBM Programming Systems are being used. Therefore, the first record (R0) of each track is used to store information about the track and contains no data. If R0 is used as a data record, storage capacity is slightly larger.</p>			

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Figure 1-7. IBM 2311 Disk Storage Characteristics

FORMAT

- Control of track format is accomplished by the SCU.
- The 'index' pulse indicates the beginning of each track.
- The 2311 model 1 has variable length records.
- The 2311 models 11 and 12 have ten sectors per track, containing a fixed count area and a 270-byte data area per sector.

Starting from index the 2311 model 1 track consists of the following areas and records:

1. Home address area (written by the disk initialization routine).
2. Record 0 (track descriptor record). Record 0 is created by a write R0 operation. R0 may be used to store customer data. IBM programming systems use R0 to describe the track's condition and enable the entire track's data to be moved to an alternate track if a portion of the recording surface becomes defective. The process of moving an entire track's data to an alternate track is called "flagging".
3. One or more variable length data records. Each record contains a count and data area, and possibly a key area between the count and data areas. The count field defines the length of the key and data areas (self-formatting).

For more information on model 1 format, refer to the 2841 Theory of Operation manual as noted in the preface.

The 2311 models 11 and 12 track consists of the following areas and records starting from index:

1. Sector 0: count area and data.
2. Sector 1: count area and data.
3. Sector 2 etc., through sector 9: count area and data.

There are ten sectors per track. Each sector is divided into two areas: count area and data area. The count area is nine bytes long plus two cyclic check bytes. The data area is a continuous, fixed-length area, 270 bytes long. Two bytes of cyclic check follow the 270 data bytes.

For more information on the format of the models 11 and 12, refer to the IBM System/360 Model 20 storage control feature or related model 20 manuals, as noted in the preface.

THE 2311 MODEL 1

The IBM 2311 Disk Storage Drive, Model 1, is the basic 2311. The model 1 is controlled by the IBM 2841 Storage Control Unit. The storage medium used with the 2311 is the interchangeable IBM 1316 Disk Pack.

The 2311 model 1 is capable of the following operations:

1. Seeks to any of 203 cylinders. A seek may be forward or backward, and from any cylinder directly to any other cylinder.
2. The 2311 can read from or write on any of the 203 cylinders, for a total of 2,030 tracks.
3. The reading or writing can be done in a completely random pattern. Only the record (key and/or data areas only) to be processed need be modified. This leaves all other records on the pack undisturbed. This is known as random access storage.
4. The records stored on a track can be of variable length. There can be a variable number of records, dependent on length, stored on a track.
5. The 2311 can store up to 7.25 million bytes or 14.5 million packed decimal digits and signs per disk pack (Figure 1-7).

Reading and writing on the disk pack is accomplished by ten R/W heads arranged in two groups of five and attached to the carriage assembly. The carriage assembly is held at a cylinder position by the detent. With the R/W heads positioned at a particular cylinder by the access mechanism, ten surfaces (tracks) can be read successively by changing the head number in the head address register (HAR).

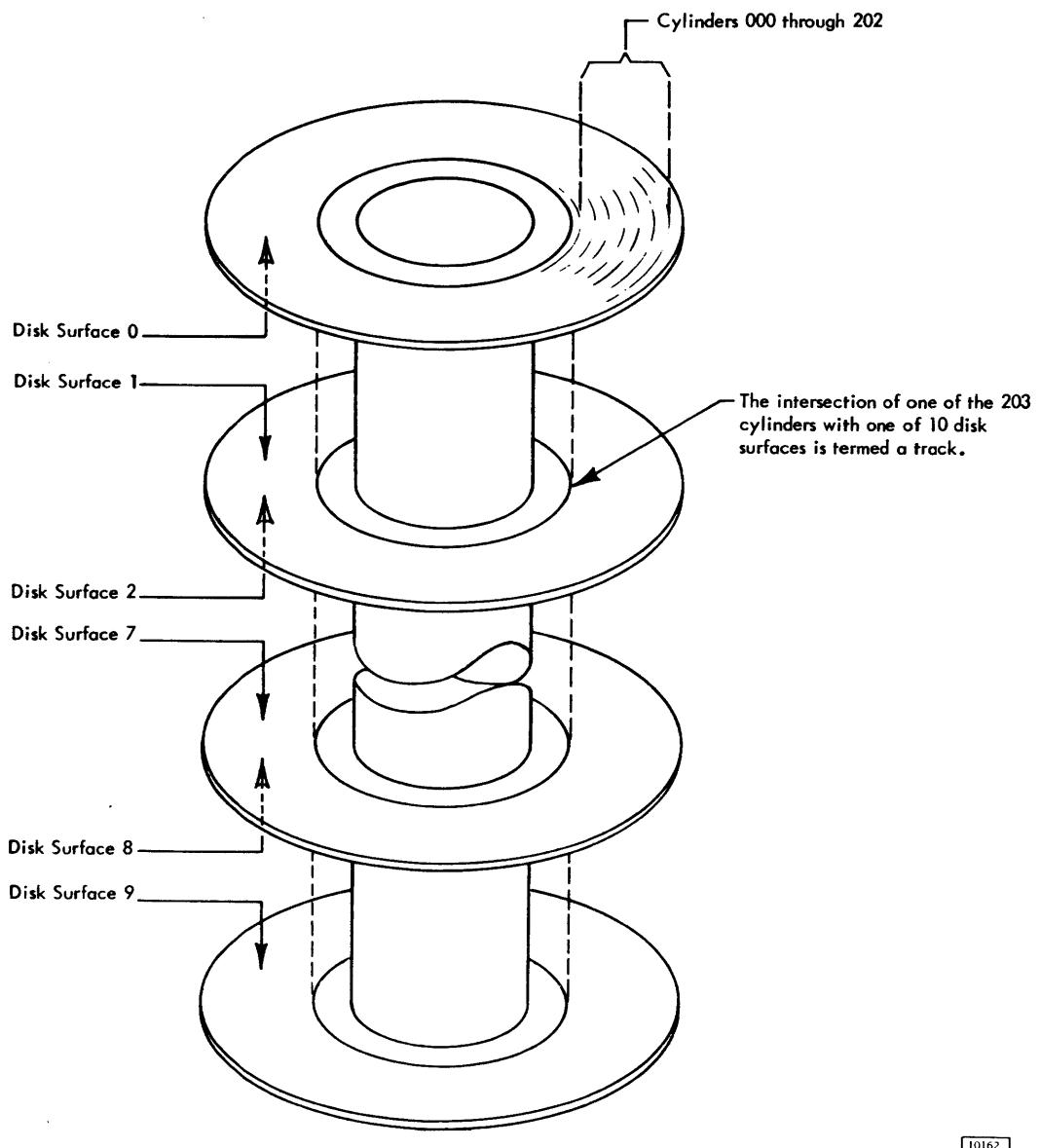


Figure 1-8. Disk and Cylinder Arrangement

The format of the records on the disk pack is controlled by the 2841. Movement of the access mechanism from cylinder to cylinder is controlled by commands issued from the 2841 but originated from the central processing unit.

Capacity of the disk pack is based on 200 cylinders. Because of the possibility of contamination of an individual track, three spare cylinders, or a total of 30 tracks, are provided for alternate use.

THE 2311 MODEL 11

The 2311 Disk Storage Drive, Model 11, is similar to the model 1. The model 1 can be field changed to a model 11. The differences are:

1. The 2311 model 11 is controlled by the System/360 Model 20 storage control feature.
2. A minor change is made in the power supply.

3. The major change is the addition of the ten-sector-generator card. This card and its associated circuitry are used by the model 20 to control the format of the records written on the disk pack.
4. Because of the sectorized format, storage capacity on the disk pack is reduced to 5.4 million maximum (Figure 1-7).

As noted in the above summary, the major difference between the model 1 and the model 11 is the ten-sector-generator circuit. The ten 'selected sector' pulses developed per disk pack revolution by this circuit are used by the model 20 SCU to control the record format on the 2311 model 11. Because of the sectorized format, there are ten records per track and all records are of a fixed length. Because of the difference in format, disk packs written by the IBM System/360 Model 20 cannot be processed by any other model of System/360.

THE 2311 MODEL 12

The 2311 model 12 is identical to the model 11, with one exception. The cylinder slotted disk (track position disk), which is used in the circuits that control movement from cylinder to cylinder, is removed and a new cylinder slotted disk is installed. The new cylinder slotted disk has approximately 38% of the slots removed. The new slotted disk limits the access mechanism to the first 102 cylinder positions. The smaller number of cylinder positions reduces the effective disk capacity to 2.7 million bytes (Figure 1-7).

The model 11 and 12 use the same record format and are controlled by the same SCU; therefore, disk packs are interchangeable between models 11 and 12. The model 12 can only access up to cylinder 102 and any data written on the pack by a model 11 above this cylinder cannot be processed by a model 12.

ACCESS MECHANISM (Figure 2-1)

- The access mechanism consists of a rack-mounted, movable carriage assembly which supports the read/write heads.
- A hydraulic actuator moves the carriage assembly. Precise positioning to any of 203 cylinders is attained by use of a hydraulically controlled detent.
- A head loading mechanism mounted on the movable carriage assembly causes the heads to move toward the disks on the first access operation and latch in place.

The carriage assembly consists of a top rail and a parallel bottom rail, separated by a T-block and a coupler plate. Both rails have bearing surfaces that act against the rollers on the carriage housing. Each rail has a gear rack that meshes with a pinion gear on the detent wheel shaft that is mounted vertically in the carriage housing. These pinion gears, along with a detent gear and a cylinder slotted disk, are pinned to the same shaft. As the carriage is moved by the carriage drive rod, a corresponding rotational movement is imparted to the detent gear and the cylinder slotted disk. A transducer senses the center of each slot and the center of each land as it passes. Movement from the center of one slot to the center of an adjacent slot corresponds to two cylinders of movement of the read/write heads.

Sensing by the cylinder transducer causes stepping of the difference counter. When the logic circuitry determines that the carriage is to stop at the addressed track, a signal to the detent solenoid causes the detent to stop the carriage. The detent transducer senses that the detent has stopped the movement of the detent gear. When the detent gear stops, the shaft, pinion gears, rack and read/write heads all come to a stop.

Also mounted on the carriage is the head loading mechanism. When the disk pack is installed, the carriage is in the retracted position with the head/arm assemblies withdrawn from the pack. The heads are also moved away from the plane of the disk surface to provide clearance between the disk surfaces and the read/write heads.

While the disks are coming up to speed, the disk brushes move into the pack on a 60 second cleaning cycle. When the cleaning cycle is complete, the read/write heads move into the pack toward the spindle. The heads are moved toward the appropriate disk surface by the head loading mechanism. An equilibrium of forces is established when the heads are loaded so that the heads "fly" at a height of 125 to 160 microinches from the surface of the disk. A wedge of air between the disk and head creates a force away from the disk, which is balanced by the force generated by the torsion rod spring. Refer to the sections on "Head Loading" and on "Read/Write Heads and Support Arm Assemblies".

HYDRAULIC DRIVE

Hydraulic Actuator

- The hydraulic actuator moves the carriage from retracted position and causes it to stop in a detented condition at any of 203 cylinders of data.
- The hydraulic actuator consists of an extend valve, an extend piston, an access piston, a direction control valve, two speed control valves, and a detent control valve (Figure 2-2).
- A constant displacement pump provides 200 psi pressure to operate the hydraulic actuators.

The hydraulic actuator (Figure 2-2) consists of an aluminum cylinder and valve block, an access piston, extend piston, and the necessary control valves. Two cylinders are bored concentrically in the cylinder block. A piston operates in each of the cylinders. The smaller of the two pistons is the access piston. It is double-acting and is connected to the movable carriage, driving it to position the read/write heads. The larger piston is the extend piston. One end of this piston is of reduced diameter and extends into the access cylinder forming a stop for the access piston. The extend piston has two positions, extended and retracted. In the retracted position, the carriage is back from its accessing region to a position where the magnetic heads are clear of the disks.

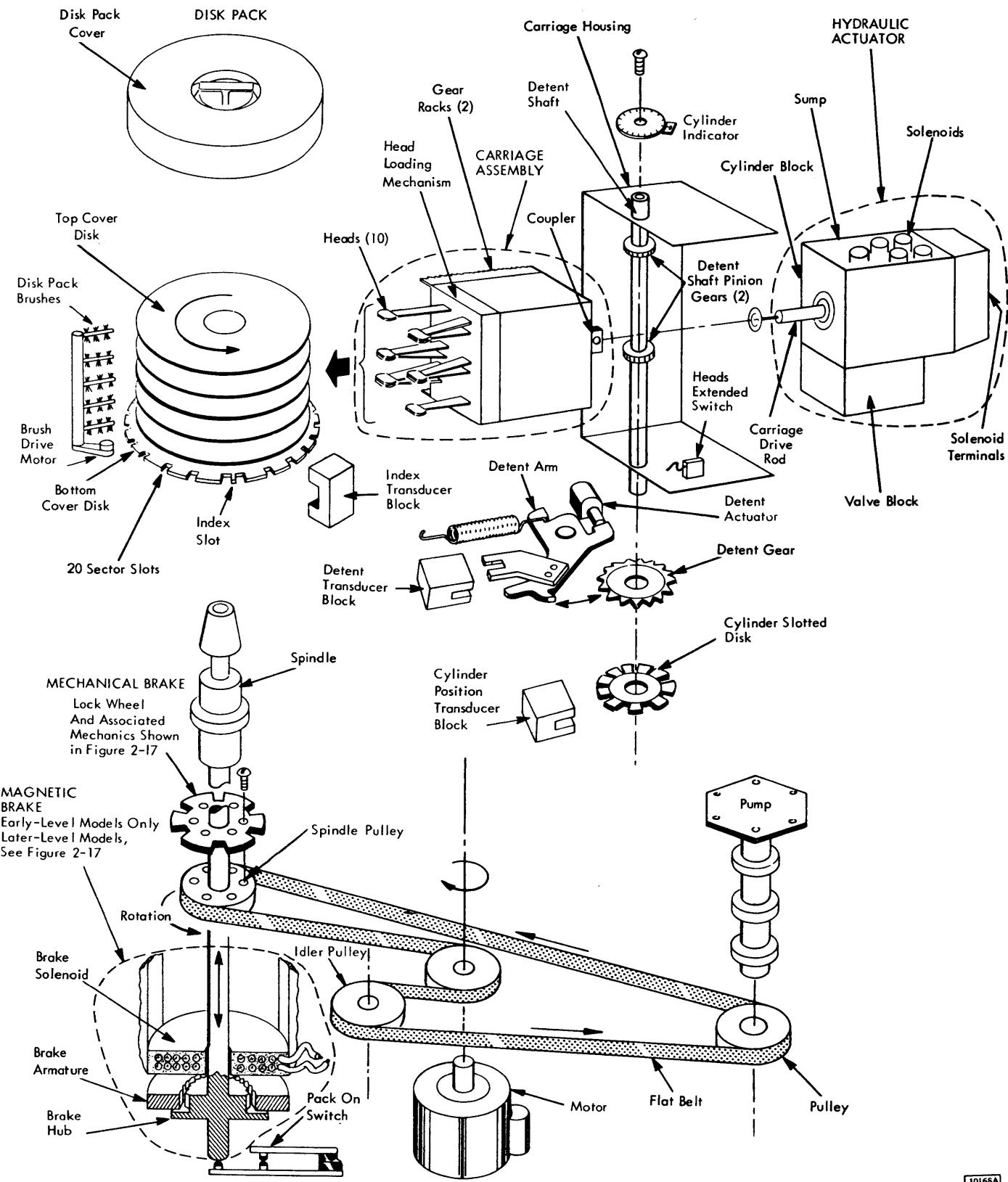
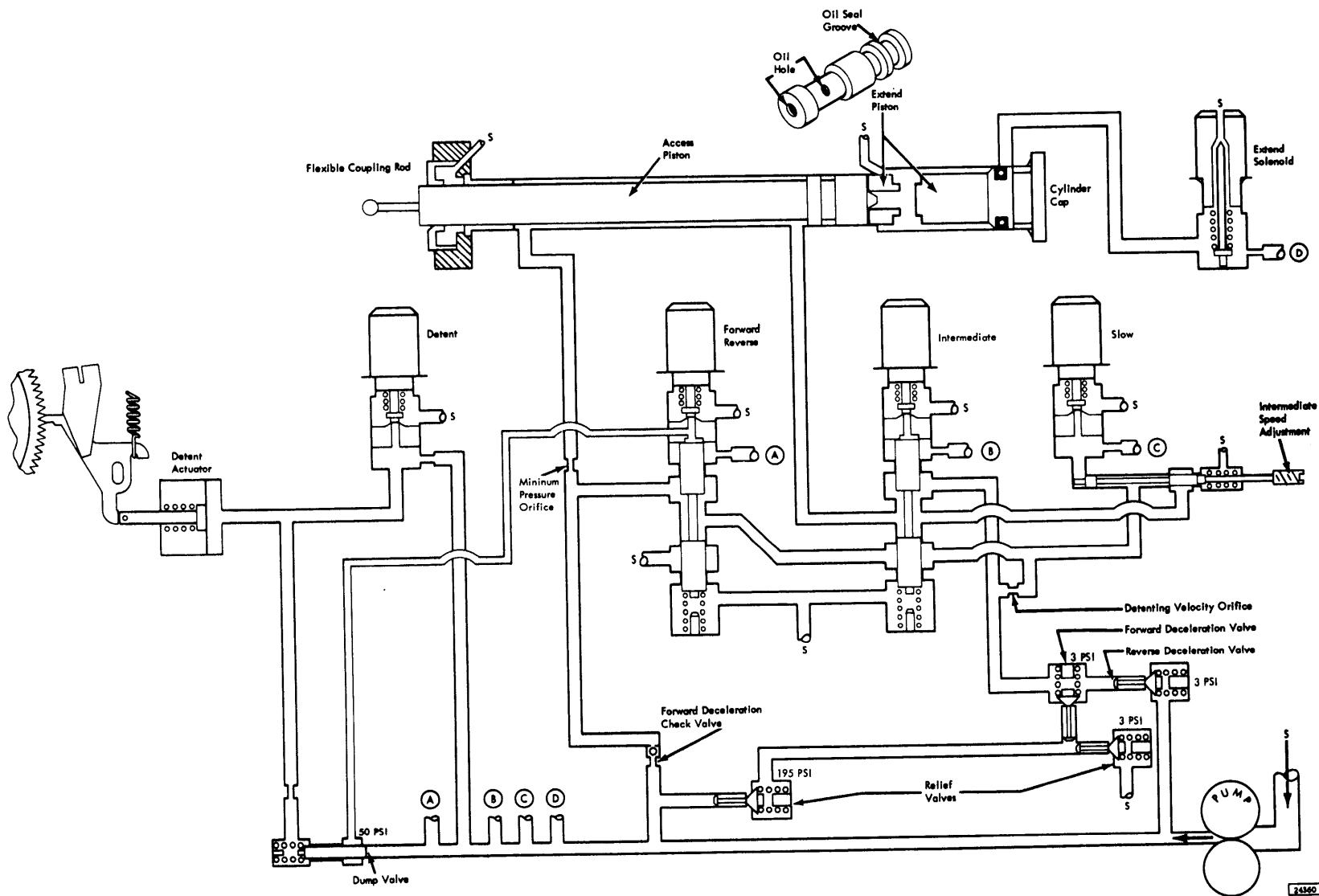


Figure 2-1. Mechanical Components

Figure 2-2. Hydraulic Actuation, Power Off



Extend Piston: Movement of the extend piston between its two positions, extended and retracted (Figures 2-2 and 2-3), is controlled by the extend solenoid valve. After the disk drive reaches operating speed, the extend solenoid is picked, the valve closes, and full hydraulic pressure is applied to the back face of the extend piston. This force keeps the piston seated against a positive stop in the extended position, where it remains during power-on. At this position, the extend piston acts as a cushioned stop for the access piston and establishes the carriage position called hydraulic home. At this time, the R/W heads are protruding into the disk pack approximately 1-1/2 cylinders before cylinder 000.

Spool Valves: Three solenoid-controlled spool valves govern the motion of the access piston: the forward-reverse valve, and the slow and intermediate speed valves. The access piston is continuously biased in the reverse direction by hydraulic pressure. Forward motion is induced when the forward/reverse valve is picked. This motion allows full hydraulic pressure to be applied to the back side of the piston. This side has twice the area of the forward side, so that a net force is applied to the carriage in the forward direction.

The speed of the carriage in fast forward travel is limited only by the flow rate of the hydraulic fluid from the pump (approximately 25 inches/second). When the intermediate valve is picked, flow to the access cylinder is diverted through two flow-limiting orifices, reducing the velocity of the carriage to the intermediate speed of approximately 7.9 inches/second. When the slow valve is picked, one orifice is cut off, and all further flow must pass through the slow speed orifice. Velocity with both flow valves picked is approximately 1.4 inches/second in forward motion, and 2.1 inches/second in reverse motion.

Forward Motion: Picking the forward solenoid actuates the forward drive, which propels the heads inward toward the center of the disk pack. The forward motion continues until the mechanism reaches a point approximately 25 cylinders from its intended destination. At this time the intermediate solenoid is picked to reduce the speed to 7.9 inches/second. Motion continues at that rate until the heads are three cylinders from their destination. The slow solenoid then is picked to reduce the velocity of the mechanism to approximately 1.4 inches/second. This slower speed permits detenting at the desired cylinder.

To move to another cylinder location, in the forward direction, the detent solenoid is dropped and the access moves at high, intermediate, and

slow speeds as before, to the new cylinder address, and the detent is engaged. If the new cylinder location is less than 25 cylinders away, the intermediate solenoid is picked immediately; for less than three cylinders, both slow and intermediate solenoids are picked immediately.

Reverse Motion: When the forward solenoid is dropped, the back side of the access piston is vented to sump; the bias pressure on the forward side of the piston drives the carriage in the reverse direction. Velocity in the reverse direction is subject to the same controls as in the forward direction. Travel in the forward direction is limited by the detent or by the positive mechanical stop. Travel in the reverse direction is stopped by switching to forward and detenting or stopped when the access piston is cushioned against the extend piston at hydraulic home. Speed of movement is identical to forward motion except for slow, which is 2.1 inches/second.

Detenting: Precise cylinder positioning is accomplished by engaging a detent with a detent gear. Linear motion of the carriage imparts a rotation to the detent gear through rack and pinion gearing. The detent gear rotates through an angle of about 351 degrees during the two-inch carriage motion from cylinder 000 to cylinder 202. The detent, normally spring-loaded into the detent gear, is held clear of the gear by hydraulic pressure acting on a diaphragm. Picking the detent solenoid relieves the hydraulic pressure and permits the detent to engage the detent gear.

HYDRAULIC OPERATIONS

As described under "Hydraulic Drive", the access mechanism is controlled by five solenoids: the extend, forward, intermediate, slow, and detent solenoids. The response of the access mechanism to the energizing of these solenoids is described in the following sections. The basic operations are described in the order in which they occur in a normal power-on seek to cylinder 000 as follows:

Power on-extend
Forward-fast
Reverse-fast
Forward-slow
Detent

In addition to these basic movements, the following also occur during accessing:

Forward-intermediate
Reverse-intermediate
Reverse-slow

Power Off (Figure 2-2)

- Zero pressure in lines.
- Extend and access piston at far right.
- Forward/reverse, intermediate, slow, and detent solenoid valves held closed by force of compression springs.
- Extend solenoid valve held open by force of compression spring.
- Forward-reverse and intermediate spool valves held in upper position by force of compression springs. Slow spool valve held to left by compression spring.

Power On-Extend (Figure 2-3)

- The 2.8 cubic inches/second pump causes 200 psi pressure in lines.
- Relief valves hold pressure at 200 psi. The 195 psi valve drops pressure to 5 psi; the 3 psi valve then drops pressure to 2 psi.
- The 200 psi pressure on the detent diaphragm pulls the detent out.
- When the pressure builds up and with the solenoids not energized, the forward/reverse and intermediate spool valves are forced down; the slow spool valve is forced to the right.
- With the extend solenoid not energized, the oil flows to the sump at the extend solenoid and the extend piston stays to the far right position (Figure 2-2).
- With the extend solenoid energized, the oil flow to sump is blocked and the extend piston moves to the left (Figure 2-3). The heads move into the pack to the home position (hydraulic home).

Forward-Fast (Figure 2-4)

- With the detent out and the access extended, the forward/reverse solenoid is energized to set up for forward motion.

- Oil flows through the valve to the sump and the pressure drop at the top of the spool valve allows the compression spring to force the forward/reverse spool valve up.
- Oil flows through the hole in the extend piston to the back of the access piston and the access piston moves to the left at fast speed.
- The heads load and latch in place near the end of the access piston's travel.
- The access piston stops in the positive stop position (crash stop).

Note that with the conditions described above, the same oil pressure exists on both sides of the access piston. The access piston is not driven to the right (Figure 2-4) since the area of the left side of the access piston is smaller than the area of the right side of the access piston. The force exerted by a piston in a hydraulic system is equal to the pressure times the area. Since the area of the right side of the piston is greater, the greater force on the right side allows the piston to move to the left.

Reverse-Fast (Figure 2-5)

- With the detent out, the access extended, and the access piston at the positive stop, the forward/reverse solenoid is de-energized to set up for reverse motion.
- Oil is prevented from flowing to the sump by way of the sump return at the forward/reverse solenoid and line pressure forces the forward/reverse spool valve down.
- Oil flow to the right of the access piston is blocked and the access piston moves at fast reverse speed toward the hydraulic home position.
- Oil flow from the right side of the access piston returns to the sump by way of: past the intermediate spool valve, past the slow spool valve, and through the intermediate spool valve to the sump.

Forward-Slow (Figure 2-6)

- The forward/reverse, intermediate, and slow solenoids are energized to set up for slow forward motion.

Figure 2-3. Power On, Extend

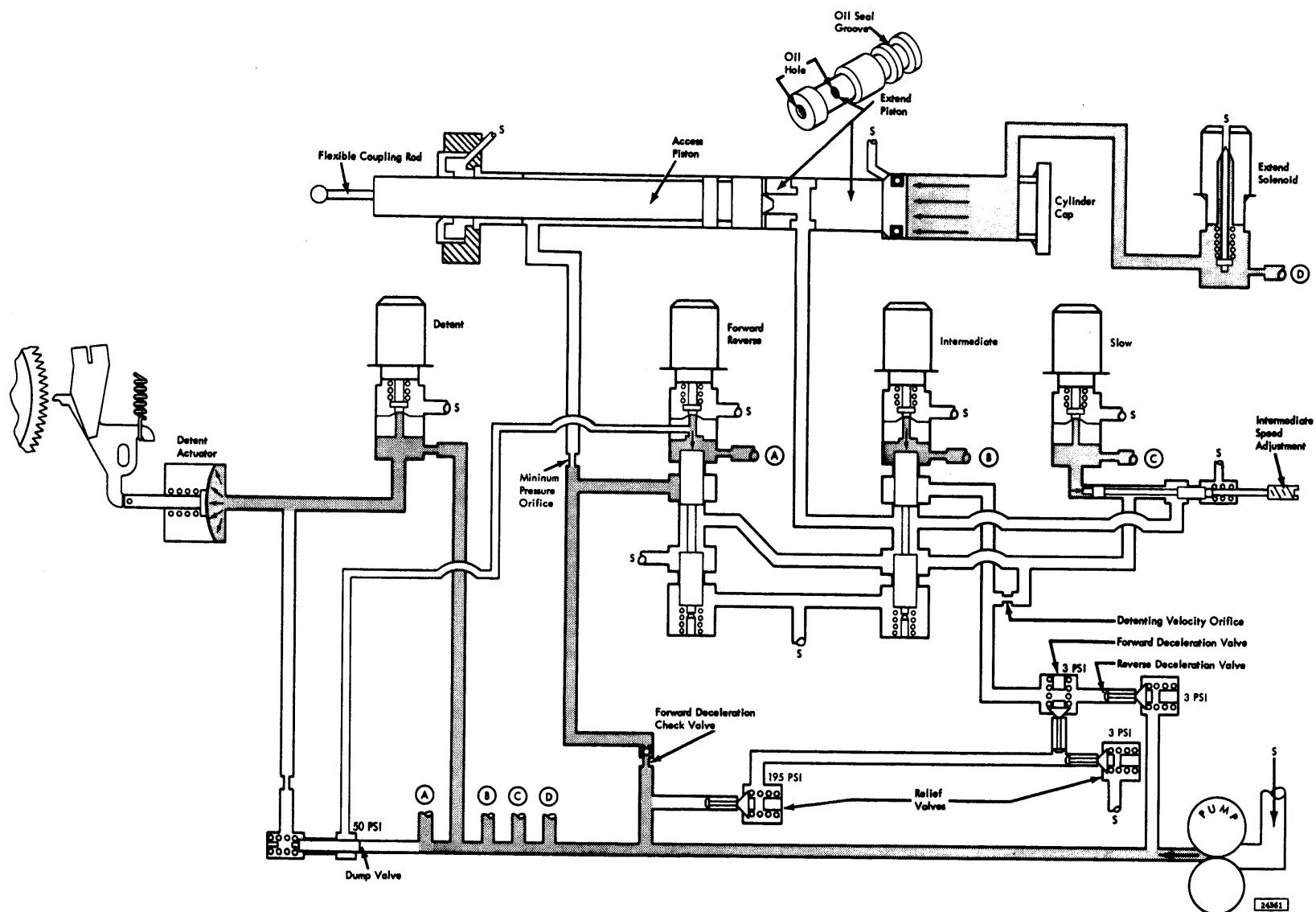


Figure 2-4. Forward Fast

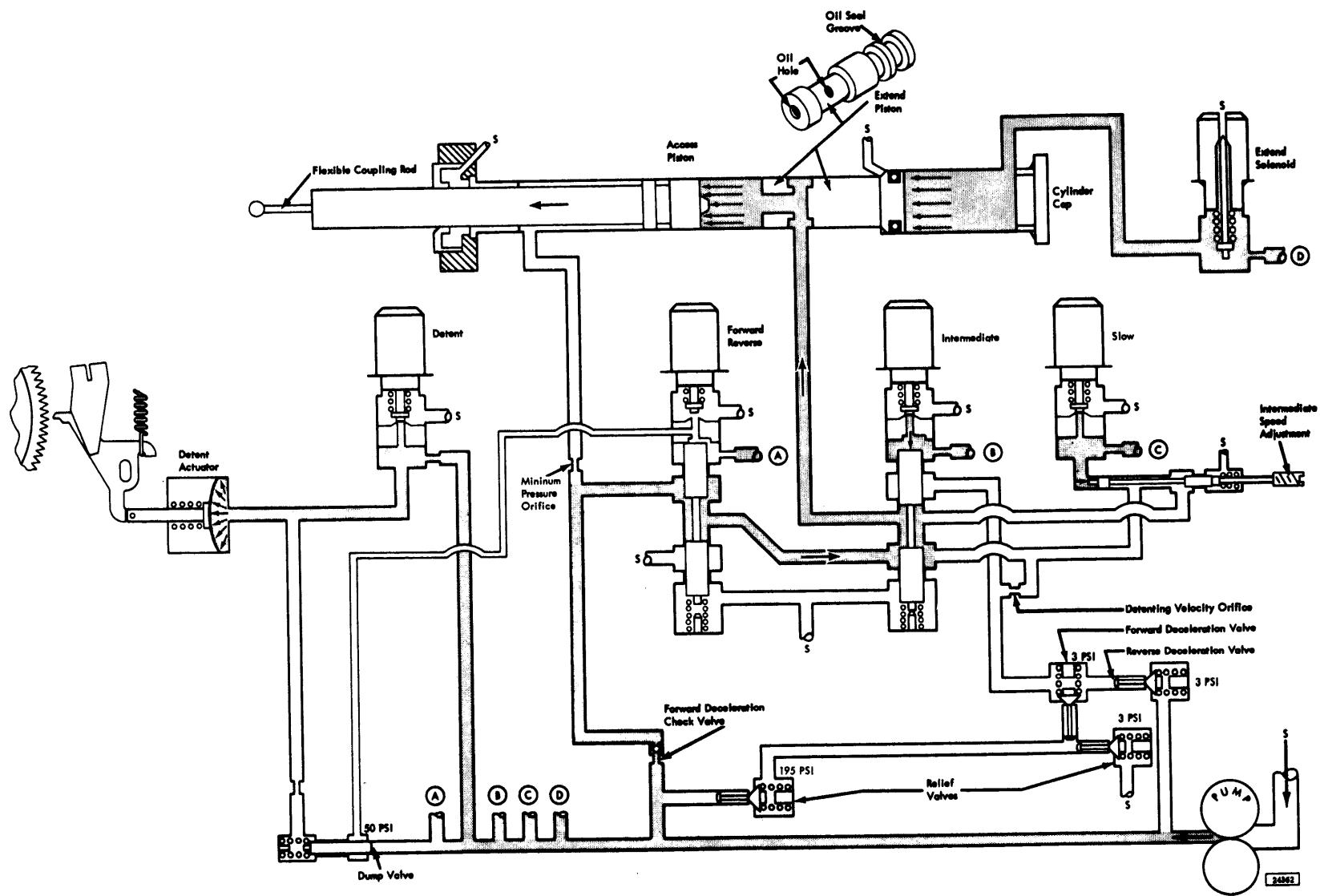


Figure 2-5. Reverse Fast

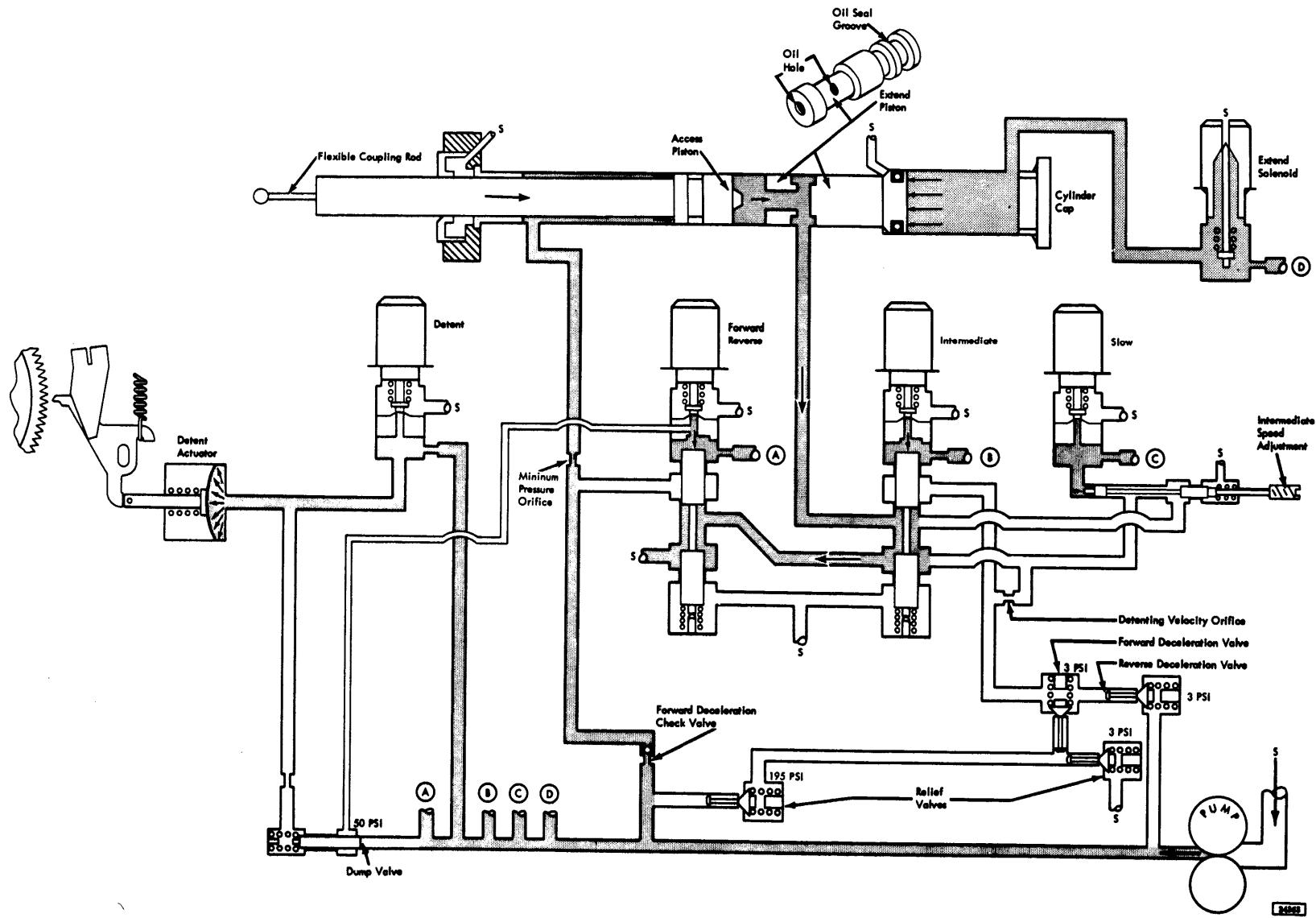
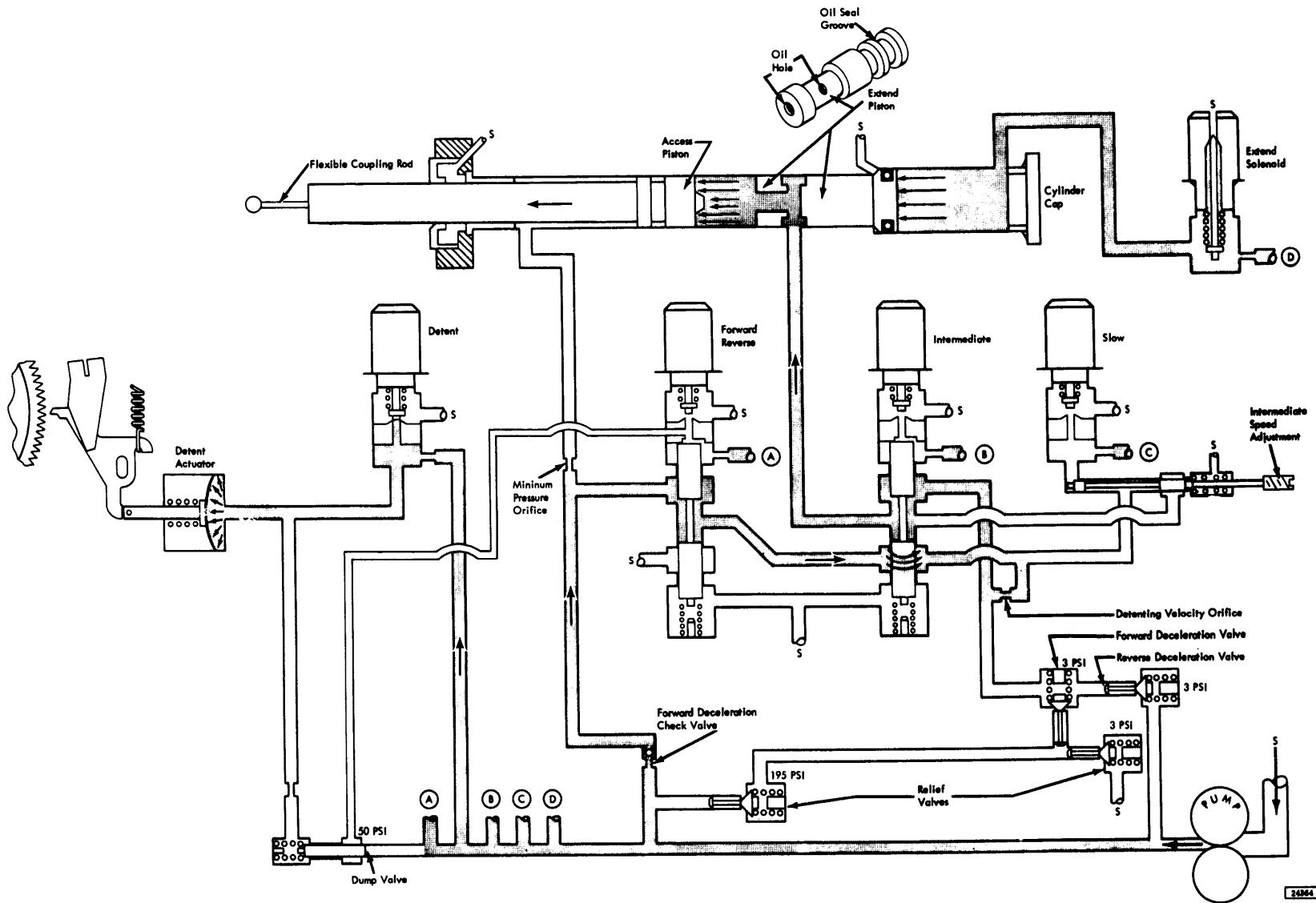


Figure 2-6. Forward Slow



- The forward/reverse and intermediate spool valves rise to their upper positions; the slow spool valve moves to the left.
- Oil flow path is around the intermediate spool valve, through the detenting velocity orifice, and through the hole in the extend piston to the back of the access piston.
- The access piston moves forward at slow speed until the first cylinder pulse is sensed (cylinder 000).

Detent (Figure 2-7)

- The detent solenoid is energized by sensing the first cylinder pulse.
- Oil flows to the sump at the detent solenoid; the detent diaphragm releases pressure on the detent which moves into the detent gear under spring tension.
- Excess heating of oil is prevented by the use of the dump valve, which is operated to bypass oil flow through the forward solenoid valve (energized) to the sump. This bypassing holds system pressure at 50 psi while the detent solenoid is operated.
- The forward and slow solenoids remain energized.

Forward-Intermediate (Figure 2-8)

- The forward/reverse and intermediate solenoids are energized.
- The forward/reverse and intermediate spool valves rise to their upper positions.
- The oil flow path is: past the forward/reverse spool valve, around the intermediate spool valve, through the detenting velocity orifice (1.75 inches/second) and the slow spool valve (6.15 inches/second) in parallel, past the intermediate spool valve, and through the hole in the extend piston to the back of the access piston.
- The access piston moves forward at 7.9 inches/second until three cylinders from the detented position.

Reverse-Intermediate (Figure 2-9)

- The forward-reverse solenoid is dropped; the intermediate solenoid is energized.
- The forward-reverse spool valve drops to the lower position, and the intermediate spool valve rises.
- The oil flow to the left side of the access piston moves the piston in the reverse direction.
- The rate of motion is controlled by the oil flow from the right side of the access piston, past the intermediate spool valve, through the detenting velocity orifice (1.75 inches/second) and the slow spool valve (6.15 inches/second) in parallel, around the intermediate spool valve, past the forward/reverse spool valve (dropped), and to the sump.
- The access moves in reverse at intermediate speed (7.9 inches/second) until three cylinders from the detented position.

Reverse-Slow (Figure 2-10)

- The forward/reverse solenoid is dropped; the intermediate and slow solenoids are energized.
- The forward/reverse spool valve drops to the lower position, the intermediate spool valve is in the upper position, and the slow spool valve moves to the left.
- Oil flow to the left side of the access piston moves the piston in the reverse direction.
- The rate of motion (2.1 inches/second) is controlled by the oil flow from the right side of the access piston, through the detenting velocity orifice, around the intermediate spool valve, past the forward/reverse spool valve (dropped), and to the sump.

HYDRAULIC POWER SUPPLY

- The hydraulic power supply for the actuator consists of a gear pump, an oil sump, and a filtering system.

Figure 2-7. Detent

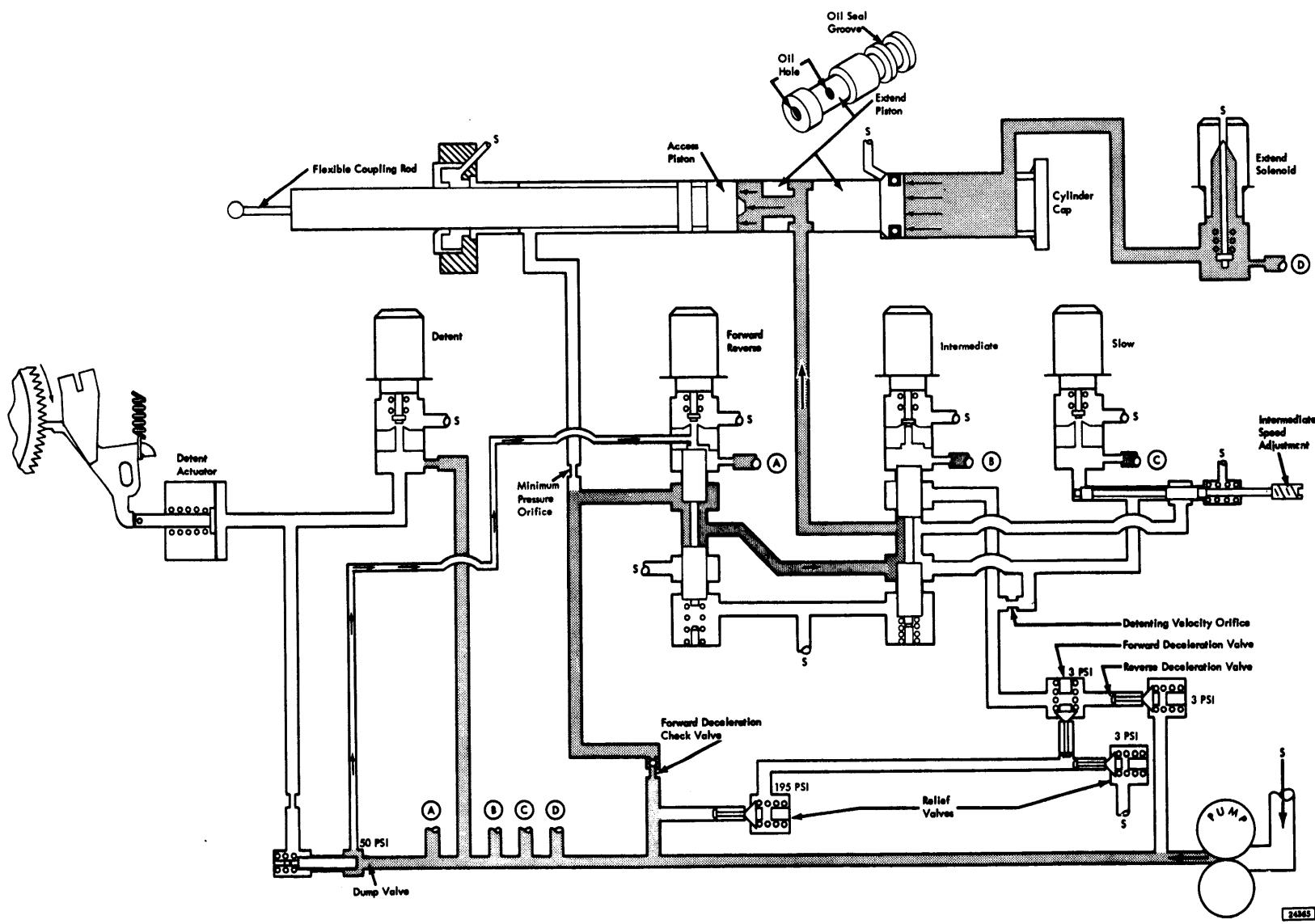
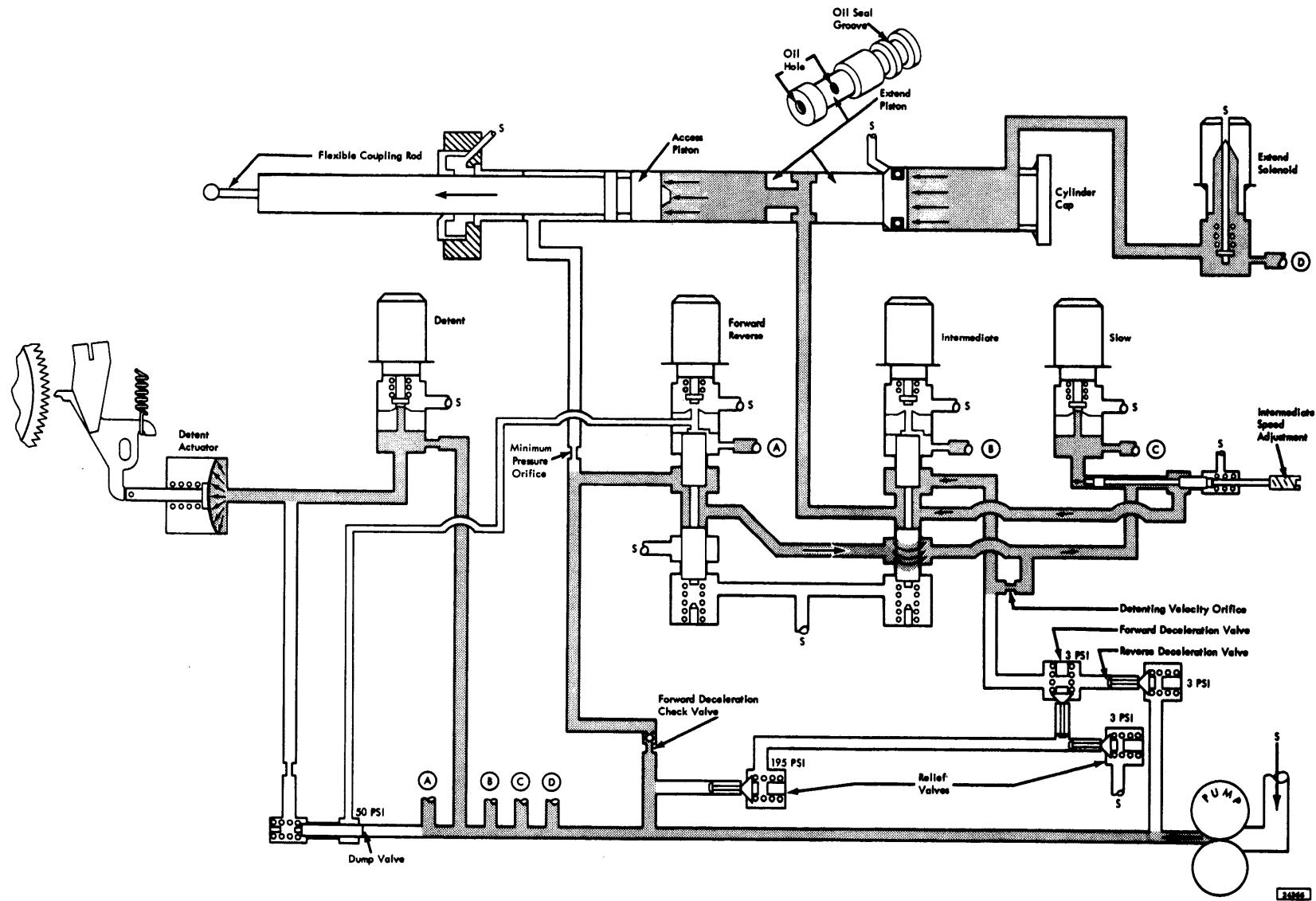


Figure 2-8. Forward Intermediate



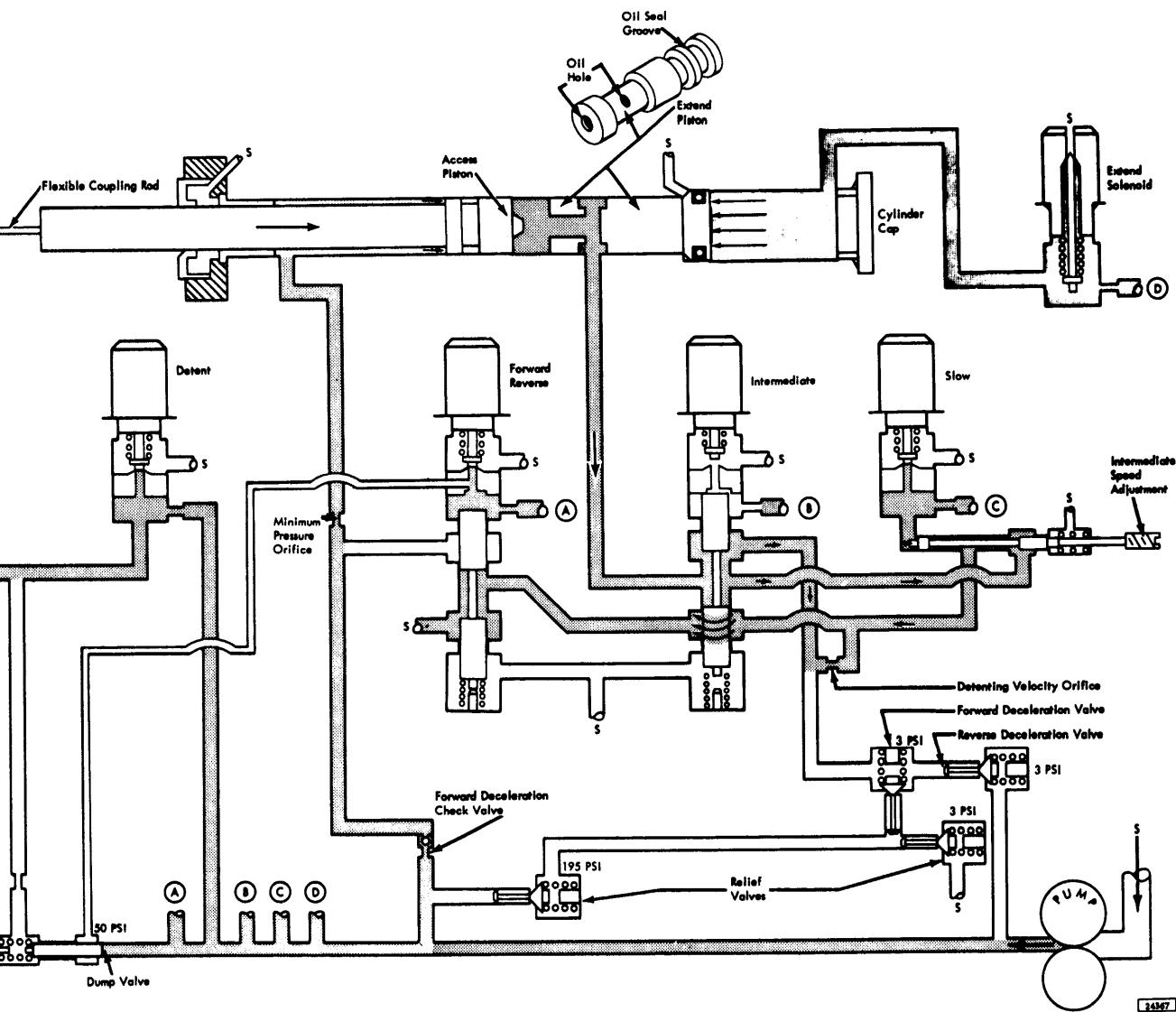
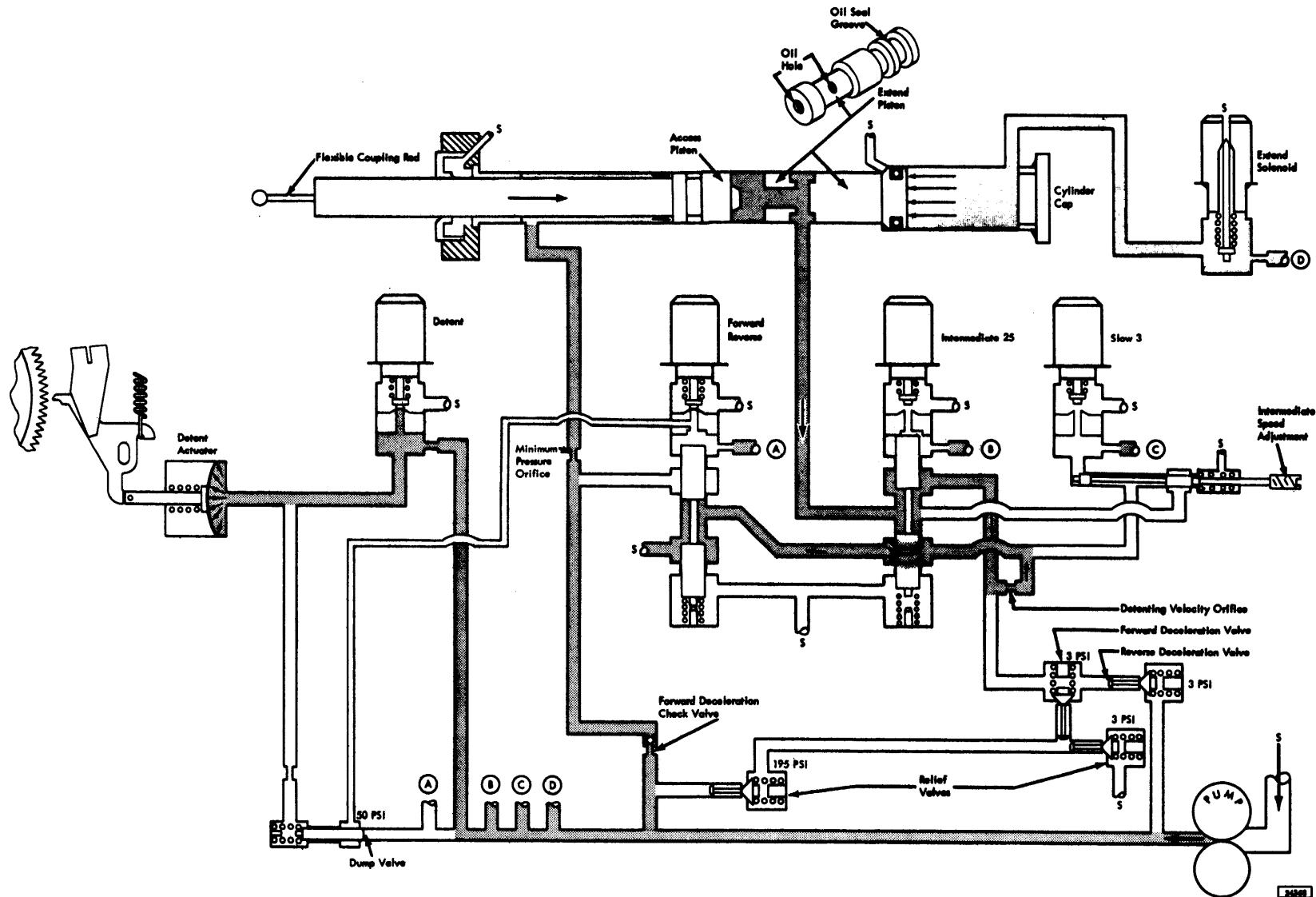


Figure 2-9. Reverse Intermediate

Figure 2-10. Reverse Slow



- The pump is a positive displacement type of 2/3-gallon-per-minute capacity at an average pressure of 200 psi.

The pump is driven by a flat belt from the disk pack drive motor. Pressure is controlled by a relief valve in the hydraulic unit. A dump valve, pilot operated from the detent pressure line, reduces power supply pressure to 50 psi during periods when the access is stationary in order to reduce oil temperature.

The sump is integral with the drive cylinder block. It contains the primary filter which is in the pump suction line. A secondary filter to remove small particles takes bypass flow from an orifice in the pressure line. A breather hole in the sump cover provides for thermal expansion and contraction of the hydraulic fluid.

On early production 2311's, an oil pressure switch transfers when the pressure approaches 0 psi. The points of the switch are used in the magnetic spindle brake circuit.

HEAD LOADING (Figure 2-11)

- With the 2311 turned off, the head/arm assemblies are in the retracted position (Figure 1-3) with the heads moved away from the plane of the disk surfaces.
- The disk pack must be up to normal running speed to create an air bearing to hold the heads the proper distance from the disk surfaces.
- After the disk pack is up to speed and the disk brushes have completed their cleaning cycle, the heads are moved into the disk pack and moved toward the disks by the head loading mechanism until the heads are positioned 125 to 160 microinches from the disk surfaces.

Turning on the start/stop switch causes the drive motor to start. This causes the disk pack to come up to speed, the hydraulic pump to operate, and the disk brushes to move into the pack. When 70% of rated speed is reached, the extend solenoid is energized. The carriage moves from the retracted position to the home position (hydraulic home). The head latch magnet is also energized at this time. After the brushes complete their cleaning cycle, the forward solenoid is energized and the carriage assembly moves toward cylinder 202 and the positive (crash) stop position. Positive stop is the mechanical limit of carriage travel toward the spindle.

As the heads move toward the center of the disk pack, head loading occurs. The carriage mounted head load cam follower (Figures 2-11b-c) moves up the base mounted head loading cam. The head-load pushrod is moved up to pivot the connecting linkage and turn the five torsion rods. Turning the torsion rods forces the ten heads toward the disk surfaces. The force applied by the torsion rod spring balances the force applied by the air cushion to create an equilibrium condition with the heads 125 to 160 micro-inches from the disk surfaces.

As the carriage approaches the end of its travel, the head latch enters the notch in the link (Figure 2-11c) and since the head latch magnet was previously energized, the heads remain latched in the loaded position under control of the head latch magnet. The heads continue moving toward the positive stop position. The head load cam follower strikes the head loading cam latch. The head loading cam pivots down (Figure 2-11c). As the head loading cam is unlatched, the heads extended switches transfer (inset on Figure 2-11c) to signal that the heads are loaded. The head latch magnet remains energized and holds the heads loaded as long as power is on, the disks are up to speed and the index block is in place.

When power is turned off (or goes off accidentally), the head latch magnet is de-energized, the latch pulls out of the link, and the torsion rods rotate so that the heads unload or move away from the disks. All solenoids are de-energized and the carriage moves toward the retracted position. As the carriage moves toward the retracted position, the stud on the carriage-mounted head load cam follower pivots the tail of the head load cam so that the cam is relatched on the head loading cam latch. The relatching takes place as the carriage moves from the home to the retracted position (Figure 2-11d).

If the heads are still loaded because of a malfunction, as the carriage approaches the retracted position (approximately minus cylinder 9), the roller arm on the carriage (Figure 2-12) strikes the knock-off plunger. This causes the head latch magnet armature to be knocked off the core which unloads the heads.

Note: This is a safety feature to prevent disk or head damage. It is not used unless a malfunction occurs.

Caution

To prevent scratch damage, the heads are loaded only after the disks are up to speed and have entered the disk pack. Similarly, the heads are automatically unloaded if power is lost and are then withdrawn from the pack.

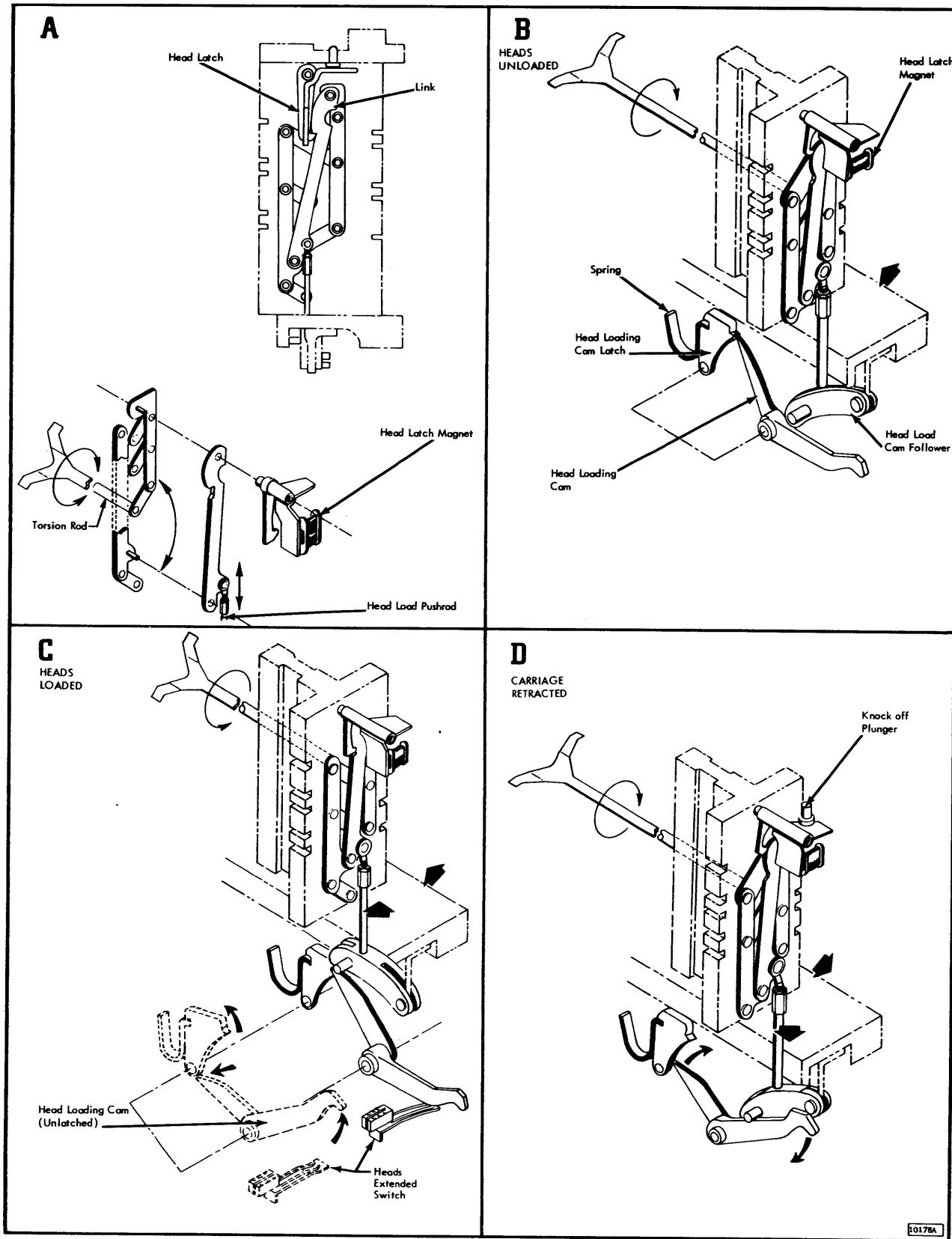


Figure 2-11. Head Load Mechanism

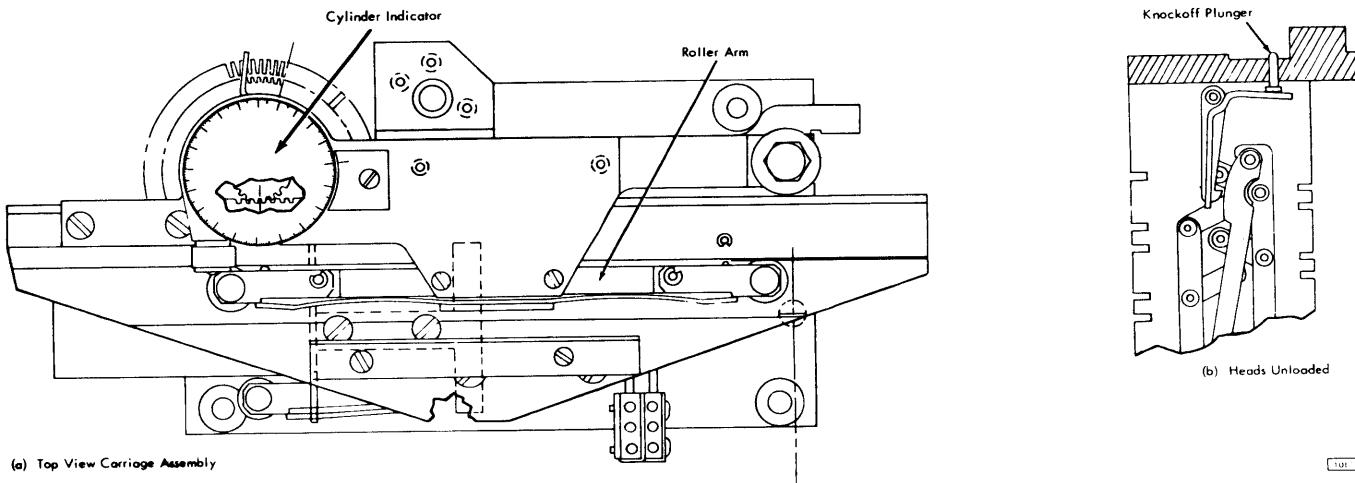


Figure 2-12. Carriage Assembly

To avoid damaging the disks, precautions must be observed when loading the heads manually. NEVER allow heads to load when power is off and disks are not revolving. Always trip the head loading latch before moving the carriage into the disks manually.

READ/WRITE HEADS AND SUPPORT ARM ASSEMBLIES

- The ten head/arm assemblies are mounted on a carriage which is driven by the hydraulic actuator.
- The read, write and erase coils are an integral part of the gliding shoe.
- The gliding shoe is designed to "fly" along the disk surface on an air bearing.
- An equilibrium of forces keeps the head at a specified distance from the disk surface.

The Head Assembly: The head assembly (Figure 2-13) consists of a head with the integral read/write and erase coils and the connecting cable and plug. The magnetic head, mounted in the gliding shoe, consists of a read/write pole gap followed by an erase pole gap. The gaps are spaced 0.045" apart. The erase coil is electrically connected to the center tap of the read/write coil and is energized whenever writing takes place. The erase pole tip is made in the form of a yoke with a 0.005" gap. This gap trims the width of the written track from 0.008" to 0.005" to

avoid fringing into adjacent tracks. Both coils are mounted on ring type structures and are assembled in the gliding shoe.

Flying the Heads: The read/write head gliding shoe floats on a film of air (Figure 2-14). The air between the gliding shoe and the disk acts as a lubricant. Air as a lubricant has two main advantages. It has a small frictional value and maintains a constant film thickness at varying temperatures.

The lubricant must separate the two surfaces so no wear or abrasion can occur. As the disk turns, the air forms a wedge between the disk and the shoe. With a given load, the shoe "flies" or balances at a height proportional to the air velocity. Thus, the gliding shoe flies at a height of 125 microinches at the inner track and at 160 microinches at the outermost track. The velocity is greater at the outer track and the induced voltage is proportional to the rate of change of flux lines with respect to time, therefore, the signal tends to be greater at the outer track.

Maintaining Disk-Gliding Shoe Equilibrium: The head must be supported so that it is held in the correct position over a track. A spring holds the gliding shoe down against the pressure of the air cushion so that the correct shoe to disk spacing is maintained. A flexure spring gives the head freedom to move around an axis tangentially and radially to the track. The head is mounted on a leaf spring which allows the head to move up and down relative to the disk surface (Figure 2-15). Together, these features allow freedom of the head to follow disk runout and allow the head to assume the correct angle with respect to the disk.

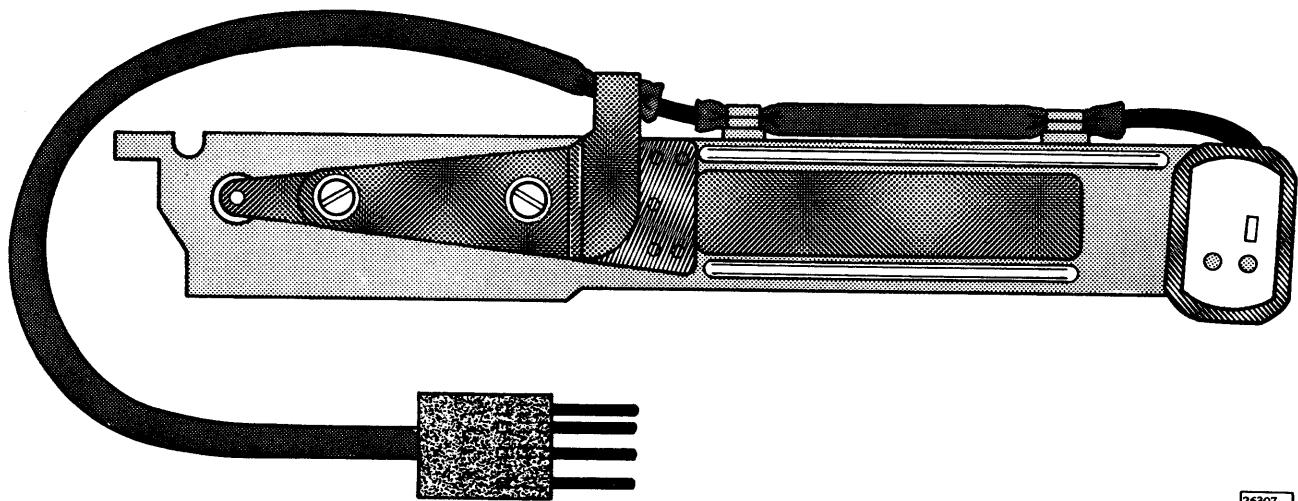


Figure 2-13. Head-Arm Assembly

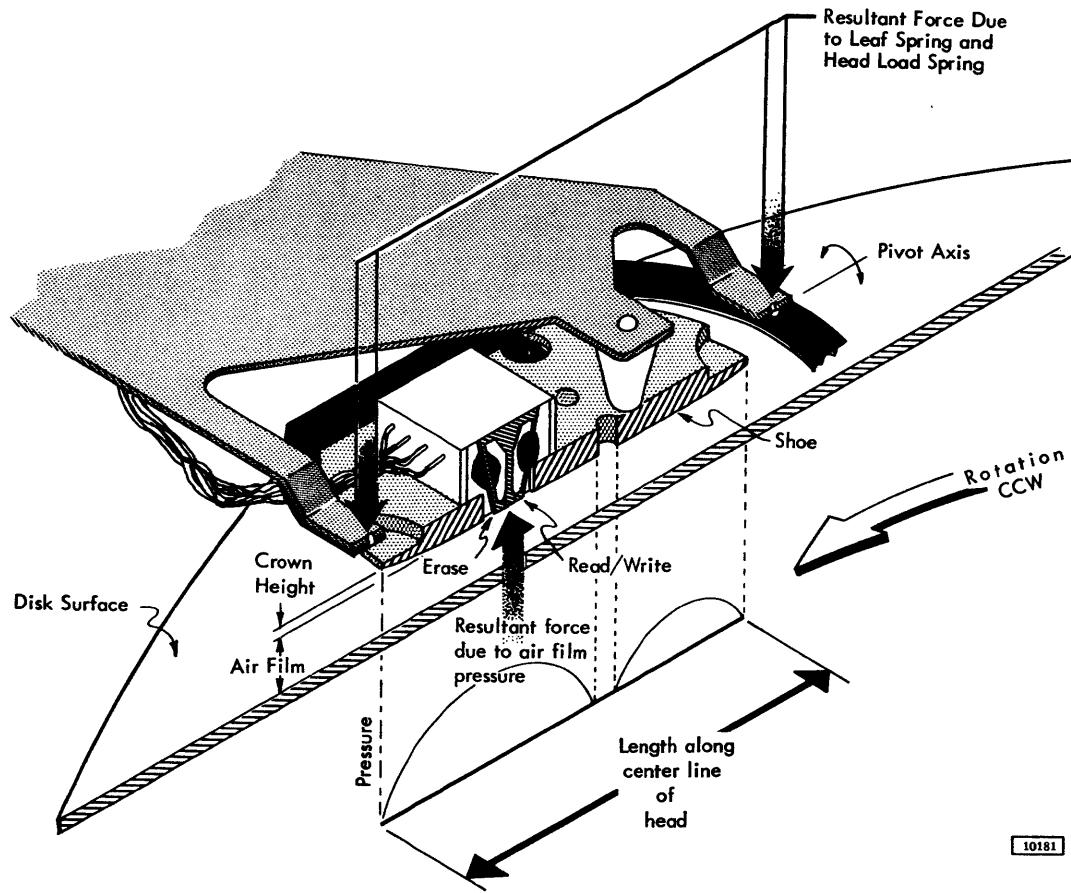


Figure 2-14. "Flying" the Read/Write Head

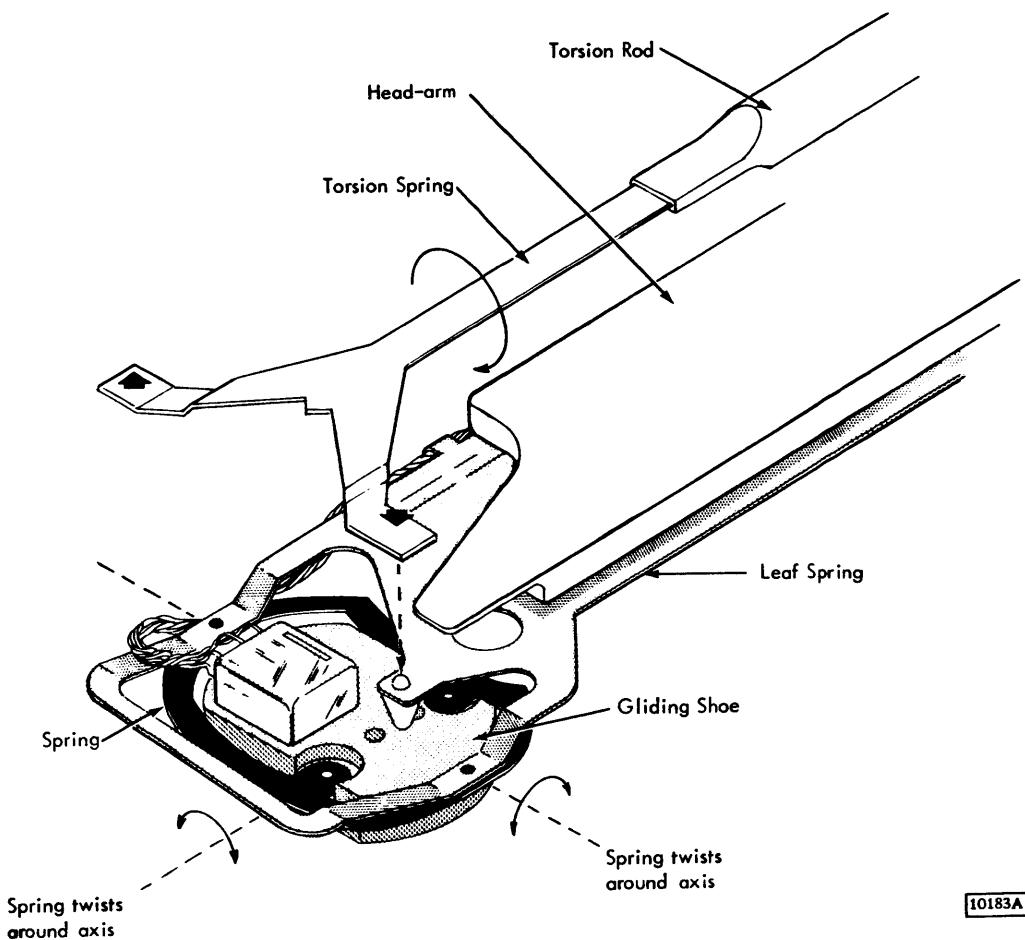


Figure 2-15. Head Assembly and Torsion Rod

The head/arm assembly is moved toward the disk into reading position (head loading) by a Y-shaped torsion rod (Figure 2-15). Each of the five torsion rods is pivoted in the block. A lever on the end of the torsion rod is attached to a linkage so that all five torsion rods are pivoted during the head loading operation. There are two types of torsion rods, one for clockwise, the other for counterclockwise rotation. Thus, the heads are loaded in pairs, one up and one down. The torsion rod bears upon a dimple on the leaf spring. Since the leaf spring is loaded with about 40 grams against the arm and a net load on the disk of about 350 grams is required, the torsion rod must furnish about 390 grams load against the leaf spring. The force generated by the wedge of air between the shoe and disk balances the force of the leaf spring. This balance maintains equilibrium so that the head flies at the specified distance above the disk.

Head Position Adjustment: The leaf spring on which the head is mounted is screwed to an arm which in turn is held in slots in a block which is part of the carriage. The head/arm assembly is adjustable in these slots so the head can be moved (Tracking Adjustment) to be exactly over the center of a particular track. The tracking adjustment can be made over a range of plus or minus one cylinder from the nominal position.

DISK PACK AND RELATED ASSEMBLIES

Disk Pack and Disk Pack Assembly (Figure 1-2)

- The disks in the disk packs have coated surfaces which can be magnetized to store bit patterns.

- The slotted bottom cover disk is used to sense disk speed, the index point and, with additional circuitry, provides sector pulses used in the models 11 and 12.
- The disk pack is assembled at the factory and should never be taken apart.

Description

The 14" diameter recording disk is a 0.050" thick aluminum disk with an overcoating of magnetic iron oxide approximately 0.0002" thick. The oxide is composed of very fine needle-like particles which are ground with other materials such as epoxy resins, thinners, and adhesives. The usable section of the disk from track 000 to 202 is about 2" with the inner track 9" in diameter and the outer track 13" in diameter. The tracks are 0.010" apart.

The top and bottom disk surfaces are not used for data storage but are protected by the top and bottom cover disks. The bottom cover disk has sector slots spaced around the outer edge. The two closely spaced slots are recognized, by the use of a magnetic transducer, as the beginning of recording (index mark) for each track. The other slots as well as the index slot are also used to sense that the disk pack is up to speed. On the models 11 and 12, the sector slots are also used to define the ten sectors (System/360 Model 20 format).

The disk pack is assembled at the factory (Figure 1-2), and should never be taken apart. The cover is designed so that it cannot be removed in normal operation unless the assembly is screwed firmly to the spindle. Once the disk pack is installed, it can be removed only by first installing the cover.

Disk Brakes

Two models of disk brakes are found on the 2311. The early-production model is the magnetic disk brake. The later-production model is the mechanical disk brake. The two disk brakes both serve the same purpose, which is to lock the disk pack spindle securely so that disk packs may be easily installed or removed.

Disk Brake, Magnetic (Figure 2-16)

In order to remove a disk pack, the start/stop switch is first turned off. In addition, the covers of the unit are interlocked so that the spindle drive motor is turned off if the cover is opened. The brake is operated by the transfer of the points of an oil pressure switch when oil pressure has dropped as a result of turning off the motor.

Disk Brake, Mechanical (Figure 2-17)

In order to remove a disk pack, turn the start/stop switch to the stop position, an act which drops power to the drive motor and causes the disk pack to coast to a stop. As the cover over the disk pack is raised, it cams the paddle downward (Figure 2-17), causing the stud and link to move toward the front of the machine. As the link moves forward, it puts pressure on the compression spring, which in turn pushes against the latch. The latch then attempts to enter a notch in the lock wheel. As the spindle turns while taking off the disk pack, the latch drops into a notch in the lock wheel and locks the spindle securely, allowing the disk pack to be unscrewed from the spindle.

If the cover is raised while the start/stop switch is on, an interlock switch will be operated and have the same effect as turning the start/stop switch to the stop position.

The cover being raised while the disk pack is still revolving causes the latch to attempt to drop into a notch in the lock wheel. The spring tension against the latch is very light, however, and the latch will be cammed away from the lock wheel by the rotating teeth in the lock wheel. This camming causes a clicking noise. The noise does not indicate trouble, nor will harm to the machine occur. If the disk pack is rotating when the cover is raised, do not attempt to manually slow the pack. Personal injury and/or disk damage could occur.

Danger

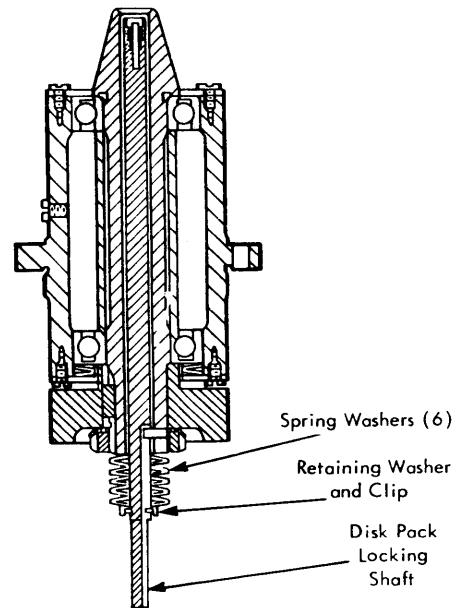
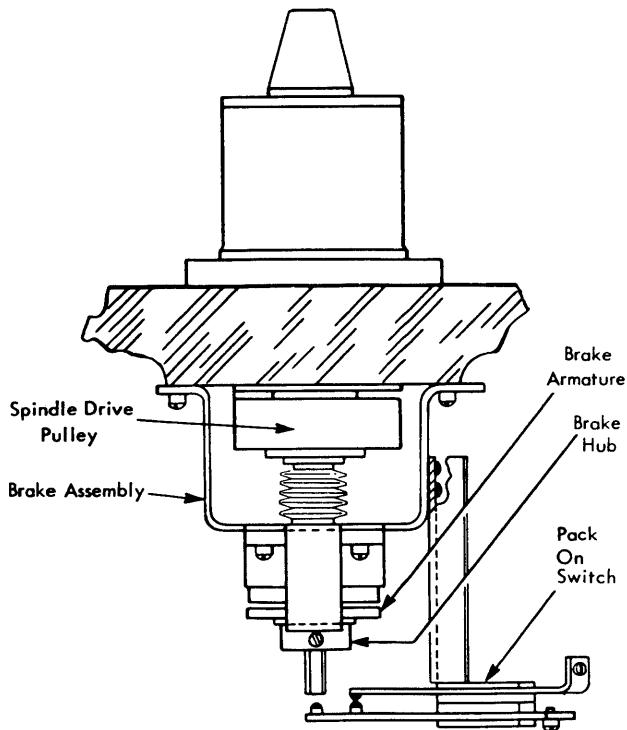
Do not manually stop the disk pack.

Disk Brushes (Figure 1-5)

- The disk brushes sweep the ten disk surfaces just prior to head loading to remove foreign particles from the disks.

The points of the drive motor relay also start the brush motor. The brushes sweep across the disks in a 60 second cleaning cycle.

If the motor should stop in the middle of a brush cycle because of a SCU power off or turning off of the 2311 start/stop switch, the brushes may be manually disengaged from the disk pack. This may be accomplished by moving the arm that appears above the pack. With the brushes pushed back out of the pack, the disk pack may be removed from the 2311. During the next power-on sequence, the brush cycle duration will be shorter than 60 seconds.



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Figure 2-16. Disk Pack Spindle Assembly (Magnetic Brake)

CYLINDER ADDRESS REGISTER

- The cylinder address register (CAR) consists of 8 binary latches (FD030).
- The CAR circuits are in the models 11 and 12 but are not used by the System/360 Model 20. (See note at the end of this section.)
- The 1, 2, 4, 8, 16, 32, 64 and 128 latches can store a range of cylinder addresses from 0 through 255.
- Addresses are stored in the CAR in true form.
- The address of the present position of the heads is gated from the CAR to the 2841 when the module is selected by a seek instruction.
- The new address is gated over the file bus lines from the 2841 to CAR at set cylinder time. This address remains in CAR until the next seek is programmed.

The eight latches (polarity hold) used in the cylinder address register (FD030) operate under control of the 'selected set cylinder' signal. The latch can change state only when the 'selected set cylinder' line is positive. The output of the latch (inverted) follows the file bus line input (Figure 2-18) only when the 'selected set cylinder' line is up.

When a module is selected by the 2841 and the initial seek has been completed, the contents of CAR (indicating the present location of the heads) are gated to the 2841 (Figure 2-19). The 2841 uses this address along with the newly addressed cylinder to compute the difference or the number of cylinders to be moved. The new address, as indicated by the program, is set in the CAR at 'set cylinder' time. For example, if the present address was cylinder 181 and the new address on the file bus line was cylinder 38, cylinder address register positions would change as follows:

CAR	Addr 181	Latch Action at Set Cylinder Time	Addr 38
128	x	Turned Off	
64		Remains Off	
32	x	Remains On	x
16	x	Turned Off	
8		Remains Off	
4	x	Remains On	x
2		Turned On	x
1	x	Turned Off	

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Note that the CAR latches follow the condition of the address bus input at 'set cylinder' time. Following the setting of CAR with the new address, the computed difference or number of cylinders to be moved is set in the difference counter triggers by the set difference pulse.

Note: The System/360 Model 20 does not use the contents of the CAR. The present cylinder address is maintained in auxiliary storage on the System/360 Model 20 CPU. When a seek instruction is given, the microprogram in the CPU uses the present address (in local storage) along with the newly addressed cylinder number, to compute the difference or number of cylinders that the access mechanism is to move.

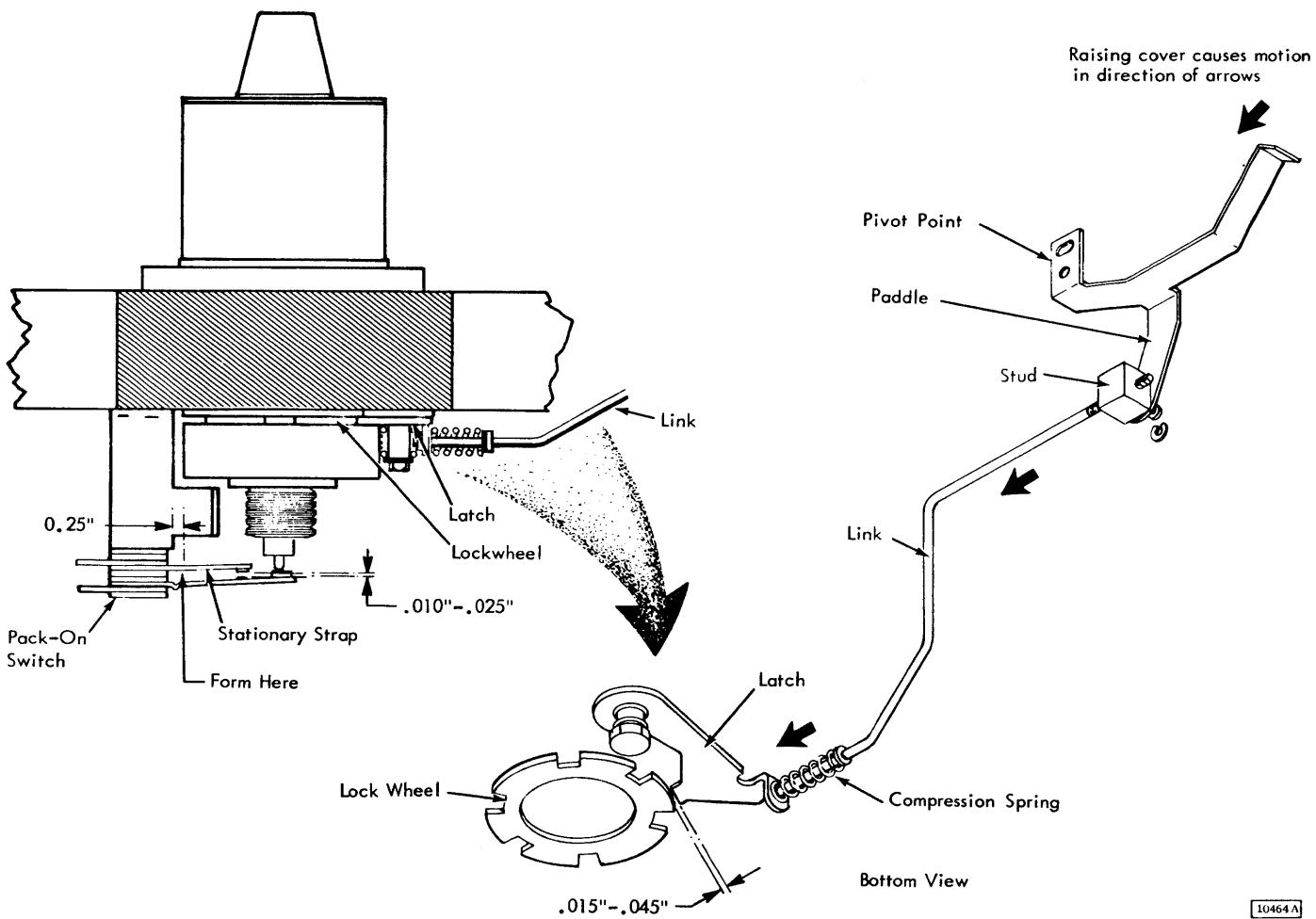


Figure 2-17. Disk Pack Spindle Assembly (Mechanical Brake)

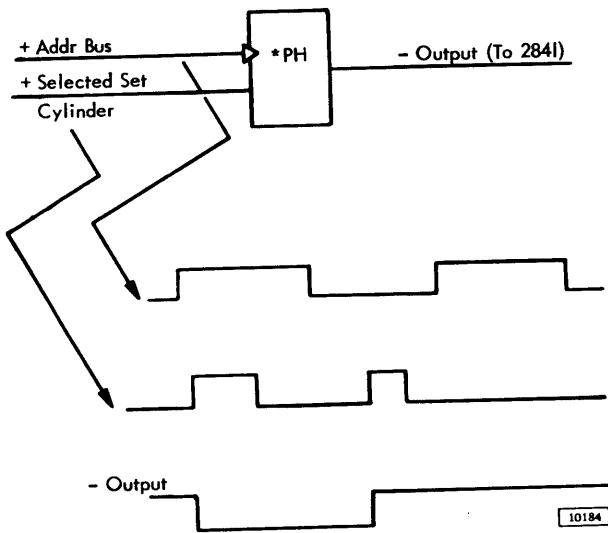


Figure 2-18. CAR Flip Latch Operation

DIFFERENCE COUNTER

- The difference counter consists of eight binary trigger circuits arranged as a decrementing binary counter.
- The difference counter outputs are decoded to develop intermediate, slow, and stop signals to control carriage travel and speed.
- All difference counter positions are set on by a 'selected set cylinder' time impulse which is supplied by the SCU.
- After the number of cylinders to be moved is determined by the SCU, the complement values of this number are turned off in the difference counter, leaving on the true value of the number of cylinders to be moved.
- Each 'gated cylinder' pulse reduces the value in the difference counter by one.

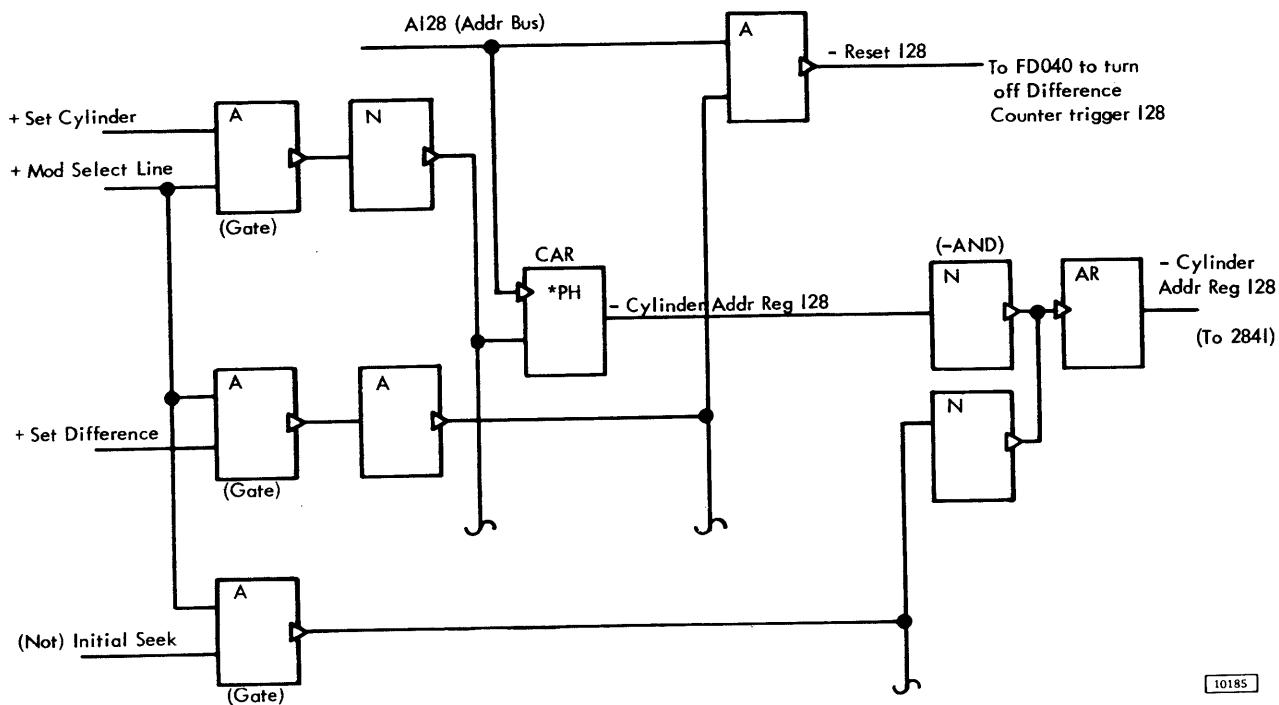


Figure 2-19. Cylinder Address Register Gating

- The difference counter trigger outputs are decoded to provide intermediate, slow, and stop signals.

At 'set cylinder' time, the cylinder address register is set with the new cylinder number and all positions of the difference counter are set on. After the difference between present head position and new head position is determined in the SCU, the complement of the difference causes the positions of the difference counter to be reset so that the true value of the number of cylinders to be moved remains in the difference counter.

Each 'gated cylinder pulse' causes the difference counter value to be reduced by one. 'Trigger one' is flipped to its opposite state whenever a cylinder pulse occurs. The turn on of 'trigger one' causes the next trigger to go on if it was off or off if it was on. The counter continues to step down as long as the subsequent trigger turns on. If a given stage is on and turns off, the counter stops until another cylinder pulse starts it again.

Example: Assume that Counter was set to 9 initially.

X = Trigger on

0 = Trigger off

— = Stop Counter Action

Trigger	Difference Counter Value									
	9	8	7	6	5	4	3	2	1	0
1	X	0	X	0	X	0	X	0	X	0
2	0	0	X	X	0	0	X	X	0	0
4	0	0	X	X	X	0	0	0	0	0
8	X	X	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
	1	2	3	4	5	6	7	8	9	
Cylinder Pulse Number										

10266A

HEAD ADDRESS REGISTER AND HEAD SELECTION

- The head address register consists of four binary trigger circuits arranged as an incrementing binary counter (FD060).

- The head address register is set from the file bus lines from the SCU at set head time.
- At index time, a head advance signal can step the head address register counter up so the next higher head value is selected.
- When the counter goes from 9 to 10, 'selected end of cylinder' signal is developed and is sent to the control unit.
- Binary output of head address register is decoded to select one of ten heads (FD065).

The head address register is reset so all four triggers are turned off by the 'control' tag with 'file bus 3' from the SCU. This occurs before the head address is set. With all positions of the register off, head 0 is addressed. Bits 8 and 2 indicate an end of cylinder. At set head time, the register is set from the file buses with the true number of the head to be selected. At the following index times, 'file bus 7' together with a 'control' tag can signal a head advance. The head advance pulse causes 'trigger one' to go on if it was off or off if it was on. 'Trigger one' going off changes the state of the following trigger. The first trigger to go on stops the counter.

Example: Assume counter was set to 0 initially.

X = Trigger On

0 = Trigger Off

— = Stop Counter action

Trigger	Head Address Register Value										
	0	1	2	3	4	5	6	7	8	9	10
1	0	X	0	X	0	X	0	X	0	X	0
2	0	0	X	X	0	0	X	X	0	0	X
4	0	0	0	0	X	X	X	X	0	0	0
8	0	0	0	0	0	0	0	0	X	X	X
	1	2	3	4	5	6	7	8	9	10	
Head Advance Pulse Number											

End of Cylinder

10267A

Head selection is made by decoding the outputs of the head address register in special AND circuits (FD065). The output of each AND circuit goes from a not selected level of +36 to 0V level to select the head. If a head is not selected, +2V level is maintained at the anode side of the read/write diodes. The diodes (Figure 2-20) are reverse biased when not selected so conduction does not take place. A special circuit (FD065) develops a 'heads unsafe' signal if more than one head is selected.

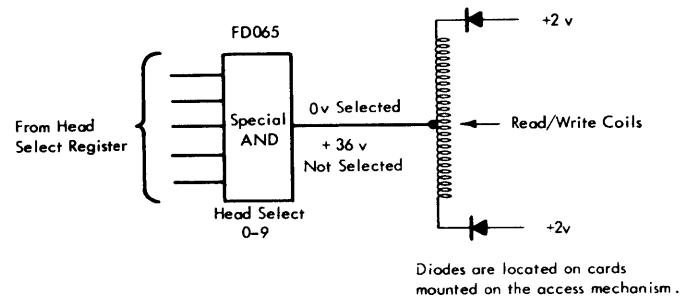


Figure 2-20. Read Write Head Selection

COMMUNICATION LINES

INPUT COMMUNICATION LINES

- The input communication interface is composed of an eight-line time-shared bus (file bus), four tag lines that select the information from the bus, a 'module select' line, and a 'write data coax' line (Figures 3-1a, 3-1b).

Since file bus lines and tag lines are common to all 2311's attached to the same SCU, a 'module select' line must be used to gate the bus lines and the tag lines to the selected module.

Only one of the four tag lines is up at a time to describe the information on the bus (Figure 3-2). The 'control' tag line gates the signals on the bus so they are recognized as control cycle lines such as 'write gate', 'read gate', etc. The 'set cylinder' tag line gates the signals on the bus so they are recognized as the signals required to identify the cylinder to be addressed. At a different time, the 'set head' tag line gates the signals on the bus so that the appropriate head is selected. Similarly, the 'set difference' line identifies the signals on the bus as the calculated difference between the cylinder at which the heads are setting and the addressed cylinder.

OUTPUT COMMUNICATION LINES

- Twenty-two output lines from the 2311 to the SCU indicate the status of the 2311.

The following output lines go to the SCU.

Gated Attention: This line indicates that the seek has been completed or that 600 ms has passed since the seek command was given without a detent-in being detected. Also, if the access is 'ready', turning the enable/disable switch to disable and back to enable provides a 'gated attention' signal to the 2841. 'Request in' is then sent to the CPU, with 'DE' status, for use by the IBM operating systems. The 'gated attention' line is reset by the 'read gate' and is not module selected.

All of the following output lines require module selection:

Selected Module: This output line is used in the 2841 in the multi-module select safety logic. The System/360 Model 20 checks only to see if a module is selected.

File Ready: This is a 'seek complete' line.

On Line: This is a line which indicates that the heads are extended and ready to read or write.

Selected Index: This is an 'index' pulse.

File Unsafe: The module is unsafe so no gates to the module from the SCU should be up.

Seek Incomplete: The access mechanism has failed to detent after a determined period of time.

End of Cylinder: The 'end of cylinder' signal occurs if during a cylinder operation, the head address register in the module goes from 9 to 0.

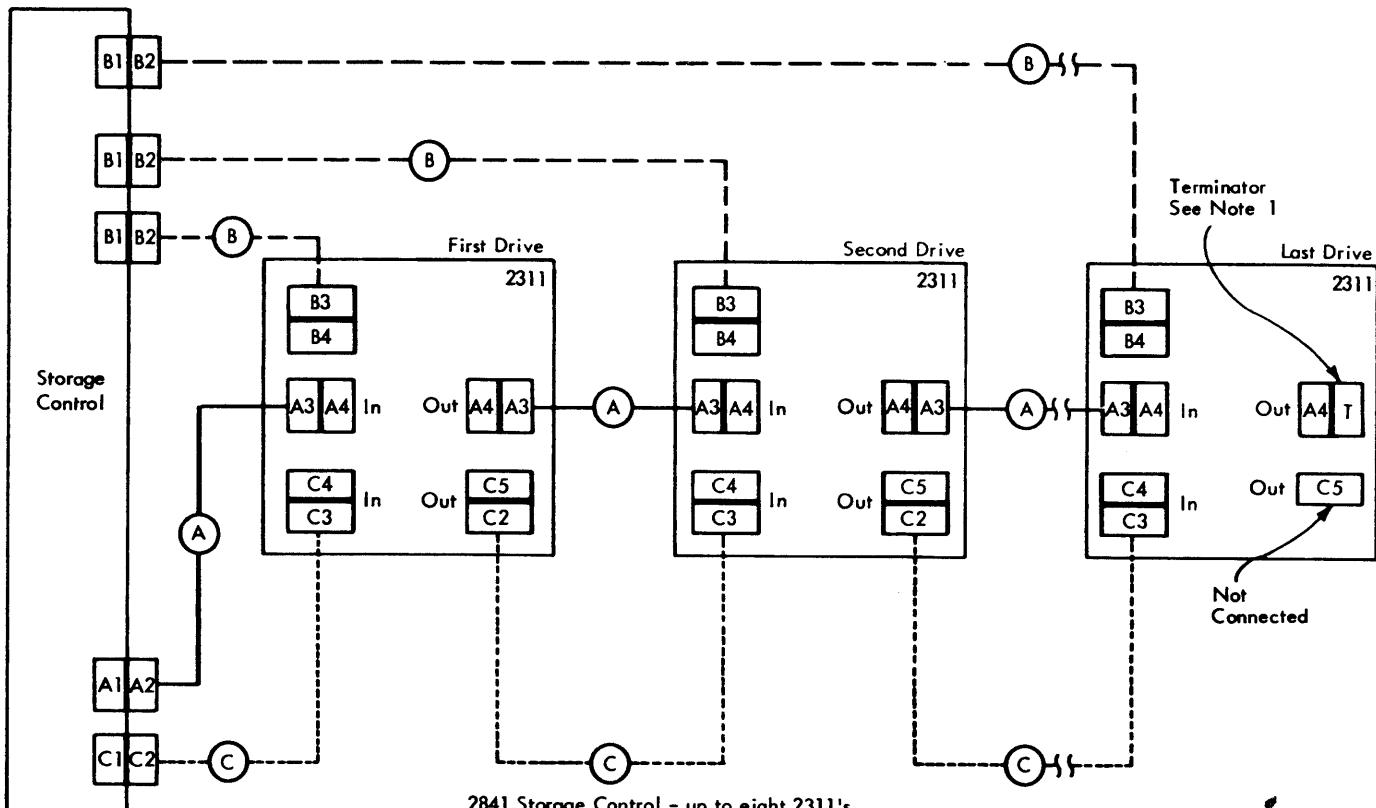
Read Data Coax: The 'read data coax' line is driven with a special line driver through a coaxial line.

Heads Extended: Indicates that heads are extended. Used in the SCU in sequencing power-off logic.

100 Cylinder File (Mod 11 and 12 only): The '100 cylinder file' line indicates which model of the 2311 is attached: model 11 has 200 cylinders; model 12 has 100 cylinders. The presence of the 4-bit in data register L indicates that a 2311 model 11 is attached.

Selected Sector (Mod 11 & 12 only): The 'selected sector' pulse defines the sector starting point on the disk surface. The leading edge of the 'sector' pulse starts the operation (read, write, scan, etc.).

Cylinder 000 (Mod 11 & 12 only): This line is active after a recalibrate operation (restore) or power on. The line indicates that a recalibrate operation (restore) or power on has occurred since the last seek operation; therefore, the cylinder number in auxiliary storage must be set to 0.



Legend:

- (B) ——— DC & Data.
- (A) ——— Signal & Sequence.
- (C) AC

Connector Location

1 on SCU.
2,3 on Cables.
4,5 on 2311 Units.

Connector Type
1,3,5 Female.
2,4 Male.

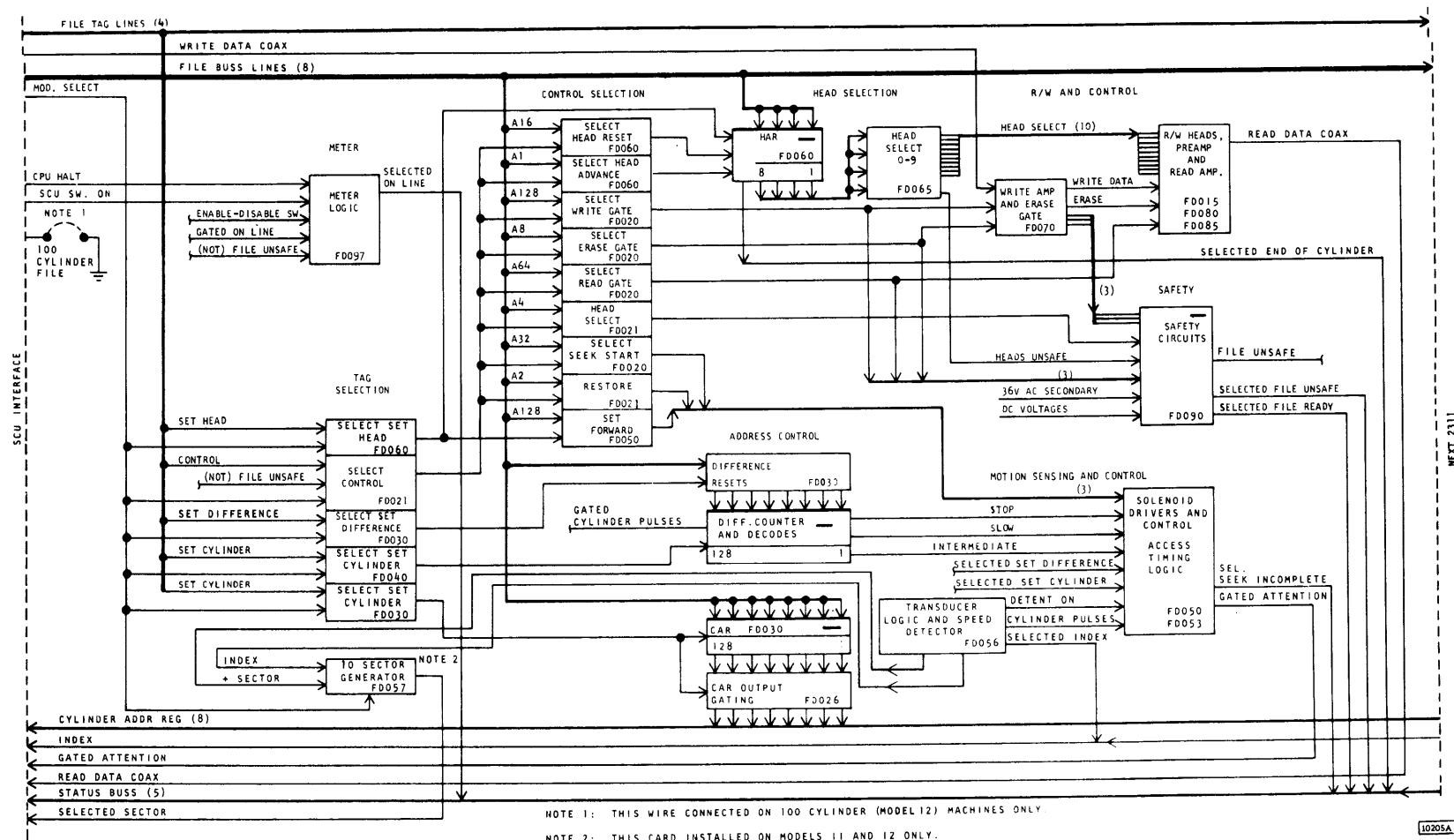
Notes:

1. Last 2311 must have a terminator part number 2181201 inserted in its signal output connector.
2. Place 2311 cables a minimum of one foot from other cables.

11576A

Figure 3-1a. SCU to 2311 Cables

Figure 3-1b. Data Flow and Control



Write Current Sense: This line was intended for use in the write safety circuits. The need for the line has never developed, and presently it is grounded in the SCU.

Cylinder Address Register: The following outputs are from the cylinder address register and are used with the 2311 model 1 only.

'CAR 1'
'CAR 2'
'CAR 4'
'CAR 8'
'CAR 16'
'CAR 32'
'CAR 64'
'CAR 128'

These output lines from the cylinder address register indicate the present cylinder address. They are present when the module is selected and are changed to a new address at 'set cylinder' time.

- Disk pack reaches 70% of final speed (cleaning cycle not yet complete).
- At 70% of speed, the next 2311 in sequence is signalled to start and the carriage extends to home position.
- After the cleaning cycle is complete, the access mechanism drives forward to a positive stop at high speed.
- Load heads while moving to a positive stop.
- Move from positive stop to hydraulic home at fast reverse speed.
- Move forward at slow speed and detent at cylinder 000.
- Signal the SCU that the access is ready.
- Generate 'attention' signal.

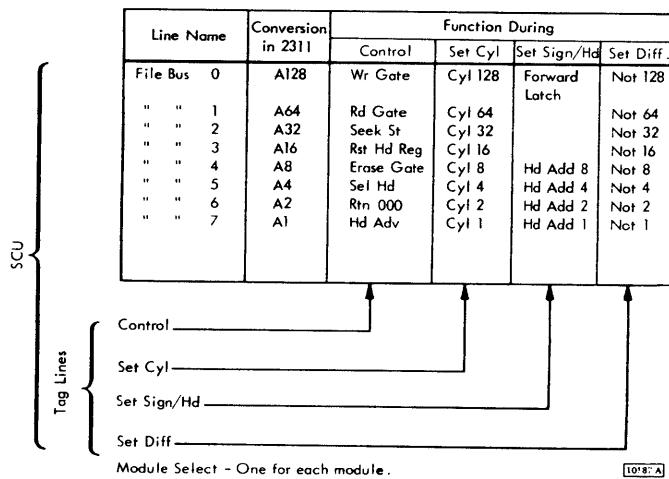


Figure 3-2. Interface Input Lines

BASIC OPERATIONS

POWER ON, FIRST SEEK OF DAY

- Disk pack installed, system and 2311 power on (Figures 3-3a, 3-3b).
- Motor starts and the hydraulic pump operates.
- Disk cleaning cycle starts and the heads are extended into the disk pack.

The brush motor relay is energized by the points of the drive motor relay to start a 60-second disk-cleaning cycle. While the brushes are sweeping, the hydraulic pressure builds up to pull the detent out of the detent gear and to provide pressure to operate the extend pistons and other hydraulic units. The access extends to home position during the cleaning cycle. At the end of the cleaning cycle, the brush switch points transfer to drop the brush relays. The drop of the brush relays cause a 'sequence start' pulse, which starts a 300 ms single shot, which momentarily inhibits the forward movement of the carriage. (Note that the 300 ms single shot provides no function at

Description

When power is turned on in the SCU, all voltages used in the disk drive module, except the +36 Vdc 8% supply, are developed in the SCU and sent to the modules. When the SCU dc voltages are available, the +36 Vdc voltage comes up in all files attached to the SCU. With 36 Vdc up in all files, a power on relay is energized in the SCU. As a result of the power on relay coming up in the SCU, R2 is picked in the first file (Figure 3-3a).

If the disk drive motor switch is on, the index block is in place (cover down) and the disk pack is in place, the drive motor starts. When the disk speed reaches 70% of its final value, the speed relay (R1) picks and a signal to the next module in sequence picks R2 to begin the drive motor on sequence for the next module.

The brush motor relay is energized by the points of the drive motor relay to start a 60-second disk-cleaning cycle. While the brushes are sweeping, the hydraulic pressure builds up to pull the detent out of the detent gear and to provide pressure to operate the extend pistons and other hydraulic units. The access extends to home position during the cleaning cycle. At the end of the cleaning cycle, the brush switch points transfer to drop the brush relays. The drop of the brush relays cause a 'sequence start' pulse, which starts a 300 ms single shot, which momentarily inhibits the forward movement of the carriage. (Note that the 300 ms single shot provides no function at

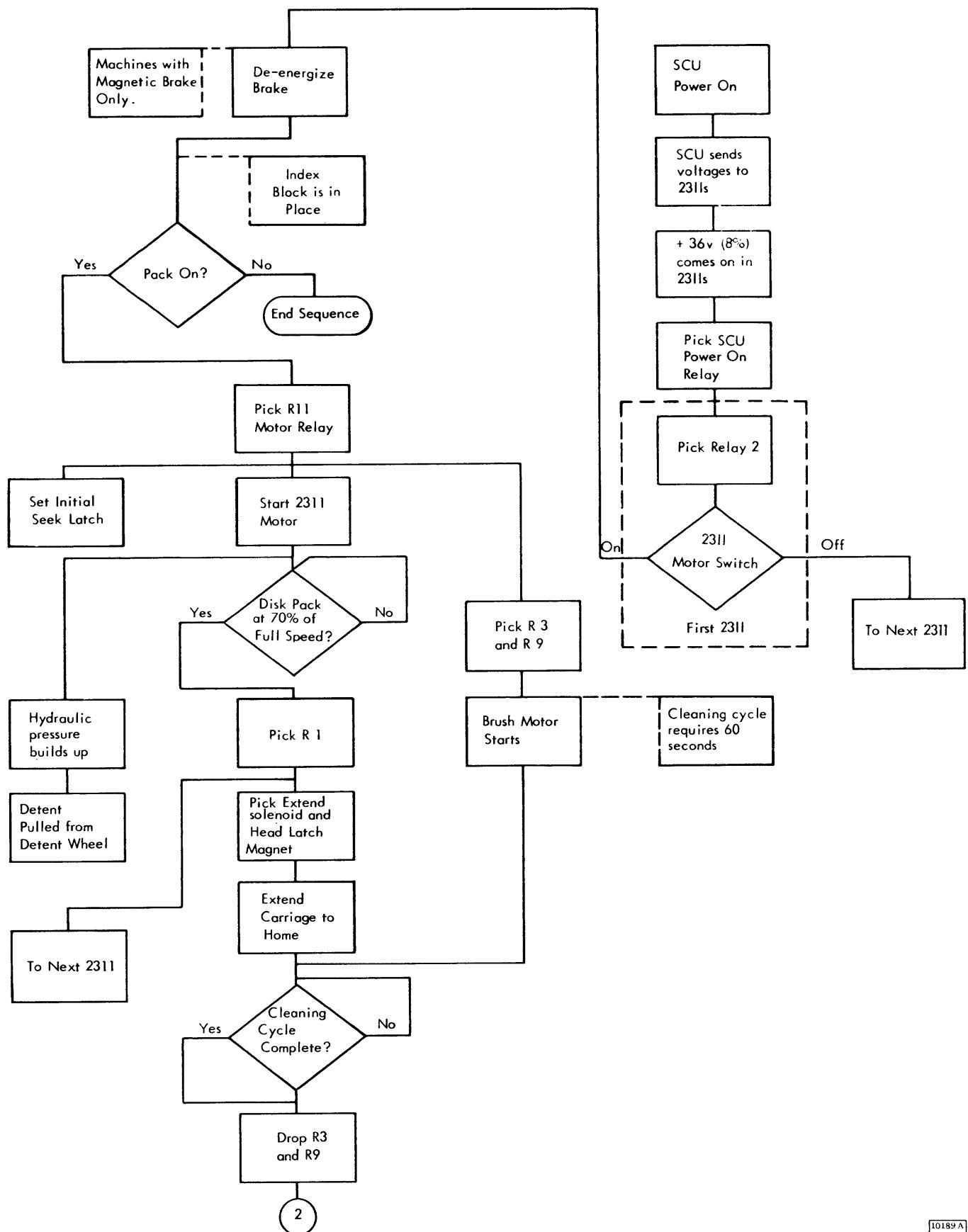


Figure 3-3a. Power On Flow Chart

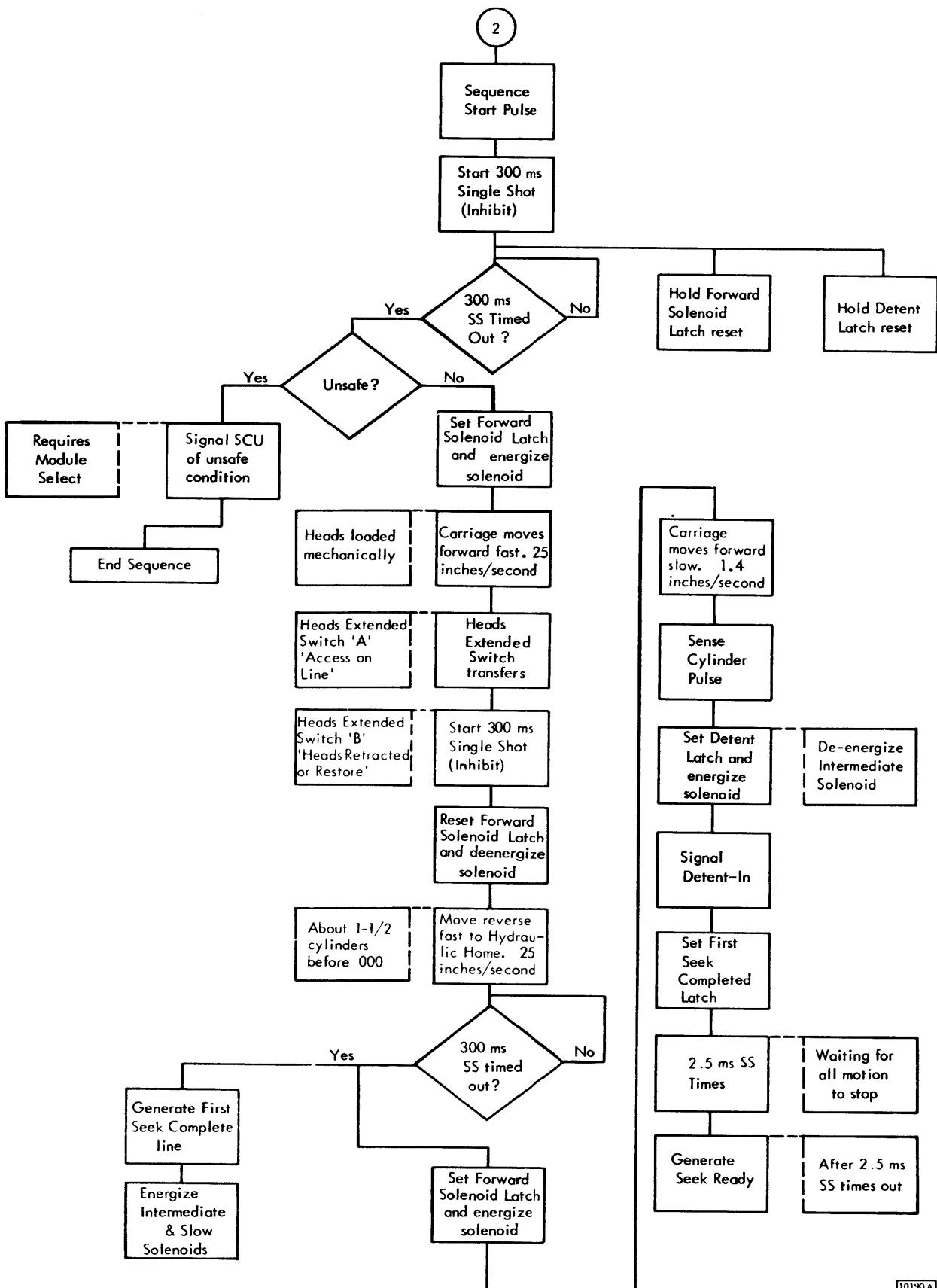


Figure 3-3b. Power On Flow Chart

this time.) If no unsafe condition exists after the 300 ms single shot has timed out, the forward solenoid is energized and the carriage moves forward at fast speed and the heads are mechanically loaded. After the heads are loaded, the head load cam is released, and the heads extended switch transfers. The heads extended switch starts the 300 ms single shot again. The single shot output brings up the 'inhibit' line which resets the 'forward' latch. Thus, the access mechanism moves in reverse for a timed 300 ms, which is long enough for the carriage to reach hydraulic home. After the 300 ms single shot

times out, a 'first seek' line comes up to energize the slow and intermediate solenoids. The time-out of the single shot also allows the setting of the forward solenoid. The access mechanism moves forward at slow speed and stops when the first 'cylinder pulse' occurs.

Circuit Objectives (Figure 3-4)

In the following sequence, power is assumed to be on with relay 2 energized.

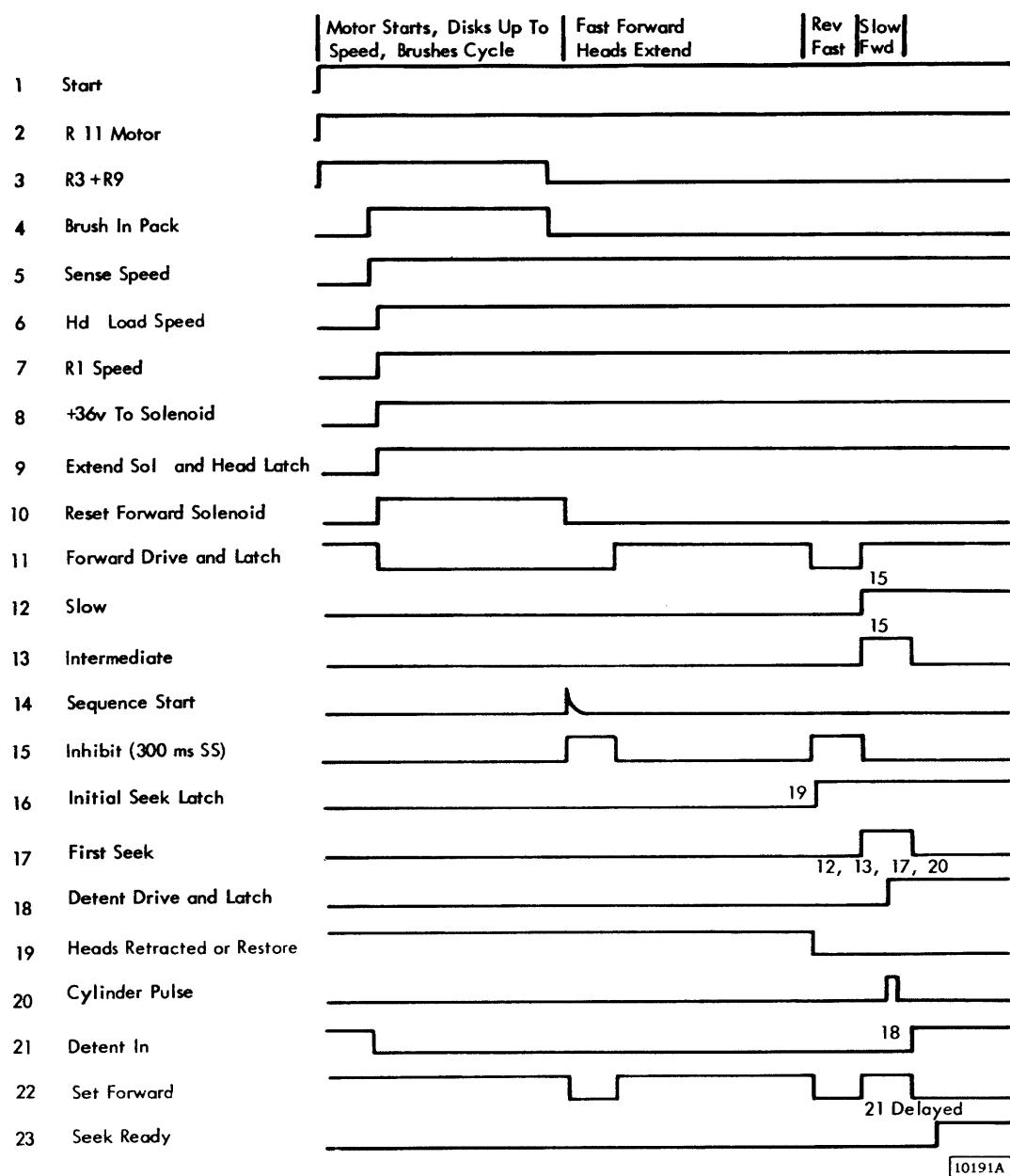


Figure 3-4. Power On Seek Timing Chart

System Diagram	System Diagram
<u>Start Drive Motor:</u> Relay 11 is energized by the start/stop switch provided relay 2 is energized and the sector block switch and pack on switch are closed.	<u>FD100</u>
<u>Release Brake:</u> The start/stop switch transfers. (Early-level magnetic brake.)	<u>FD100</u>
<u>Start Brush Motor:</u> R3 and R9 are energized by the R11-2 points. The circuit is completed to ground through the diode and R1-3 n/c because head load speed has not been reached. When the brush motor starts, the brush motor switch transfers to the n/c position and establishes a second hold path for R3 and R9. Shortly after the second path is established, head load speed is reached and R1 picks, dropping out the first hold circuit through the diode. When the 60 second cleaning cycle is completed, the brush motor switch transfers back to the n/o position and drops R3 and R9, causing the brush motor to stop.	<u>FD100</u> <u>FD105</u> <u>FD110</u>
<u>Energize Extend and Head Latch Magnets:</u>	
1. The gate +6 volts line, with brush motor switch transferred to n/c point, develops the 'sense speed' line (R1- n/c). 2. The speed detector card senses 70% speed and energizes R1. 3. The R1-3 point energizes the extend and head latch magnets.	<u>FD100</u> <u>FD105</u>
<u>Move Carriage Forward and Load Heads:</u> (forward solenoid on FD105).	
1. Relay 3 drops when the brush cycle is complete. R3-3 causes the 'sequence start' pulse. 2. The 'sequence start' pulse starts the 300 ms SS (inhibit). 3. When the SS times out, the 'set forward' line is developed because the 'first seek completed' latch is off. 4. The 'set forward' line turns on the forward solenoid latch. 5. Set the forward solenoid. 6. The carriage moves forward fast, the heads are loaded, and the heads extended switch A transfers, bringing up the 'access on line' signal.	<u>FD100</u> <u>FD053</u> <u>FD053</u> <u>FD050</u> <u>FD105</u> <u>FD100</u>
<u>Heads extended switch B transferring causes the 'heads retracted or restore' line on FD053 to go to plus 6 Vdc.</u>	<u>FD053</u>
<u>Move Carriage Backward to Home:</u> (De-energize the forward solenoid on FD105.)	
1. The '[not] heads retracted and re-store' line starts the 300 ms SS (inhibit). 2. Forward solenoid latch held off for 300 ms by 'inhibit' line. 3. The '[not] first seek completed' latch blocks 'slow' and 'intermediate' lines. 4. The carriage moves backward at fast speed and reaches hydraulic home before the 300 ms SS times out. 5. Block 'gated cylinder pulse' during backward movement because 'first seek completed' latch is not on. 6. The carriage stops at hydraulic home and waits for the 300 ms SS to time out ('[not] inhibit').	<u>FD050</u> <u>FD050</u> <u>FD053</u> <u>FD053</u>
<u>Move Carriage Forward at Slow Speed and Stop at Cylinder 000:</u>	
1. The 'set forward' line is developed by '[not] first seek completed' and '[not] inhibit' when the 300 ms SS times out. 2. The 'forward solenoid' latch is turned on because '[not] inhibit' and '[not] reset forward' lines are up. 3. The 'first seek' line is developed by '[not] heads retracted or restore', '[not] first seek completed', and '[not] inhibit'. The 'first seek' line develops the 'slow' and 'intermediate' lines. 4. Carriage moves forward at slow speed. 5. 'Detent' latch set by first 'cylinder' pulse and 'first seek'. 'Intermediate' and 'slow' lines are up. 6. 'Intermediate' line drops because the 'detent' latch comes on. 7. Detent solenoid energized to stop carriage at cylinder 000.	<u>FD053</u> <u>FD050</u> <u>FD053</u> <u>FD050</u> <u>FD050</u> <u>FD105</u>
<u>Set First Seek Completed Latch:</u> The 'first seek completed' latch is turned on by the 'detent in' output of the detent transducer. The latch remains on until the heads unload. The 'first seek	<u>FD053</u> <u>FD050</u>

System Diagram

'completed' latch coming on causes the 'first seek' line to drop. The 'first seek' line dropping causes the 'intermediate' line to drop. The 'slow' line is held up by the 'detent latch' line.

Signal Attention to SCU: Gated attention signal to SCU occurs after 2.5 ms SS (started by 'detent in') times out.

FD053

PROGRAMMED FORWARD OR REVERSE SEEK, 2311 MODEL 1

- Select the 2311 (Figures 3-5a, 3-5b, 3-5c, 3-5d).
- Send the present 2311 cylinder location from the cylinder address register (CAR) to the 2841.
- Set the desired cylinder address in the 2311 CAR.
- Determine in the 2841 the number of cylinders to be moved by the access, and set the 2311 difference counter to this number.
- Set either forward or reverse condition as determined in the 2841.
- Pull the detent and begin either forward or reverse movement.
- Slow to 7.9 inches/second when 25 cylinders from addressed cylinder.
- Slow to 1.4 inches/second (2.1 inches/second if reverse motion) when three cylinders from addressed cylinder.
- Stop when the difference counter indicates that the access is at the desired cylinder. (All triggers are off.)
- Signal 'gated attention' to the 2841 to indicate that the seek is finished.

Description

The 2311 is first selected by bringing up the appropriate 'module select' line in the 2841. Because the 2841 must determine how many cylinders the access must move from its present location to the newly addressed location, a means must be provided to

determine whether the access is at cylinder 000 or at some other location (Figure 3-5a). The access is at cylinder 000 if a power on seek has occurred or if a 'recalibrate' (restore) was signalled by the

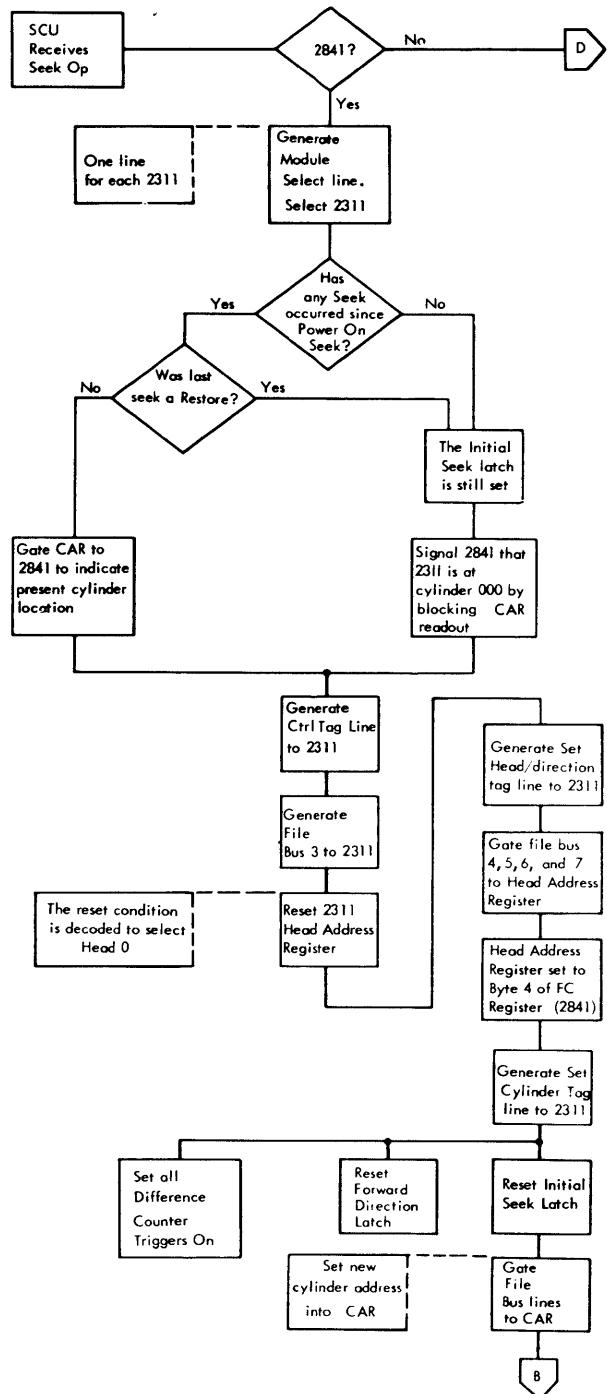


Figure 3-5a. Programmed Seek Flow Chart

10152

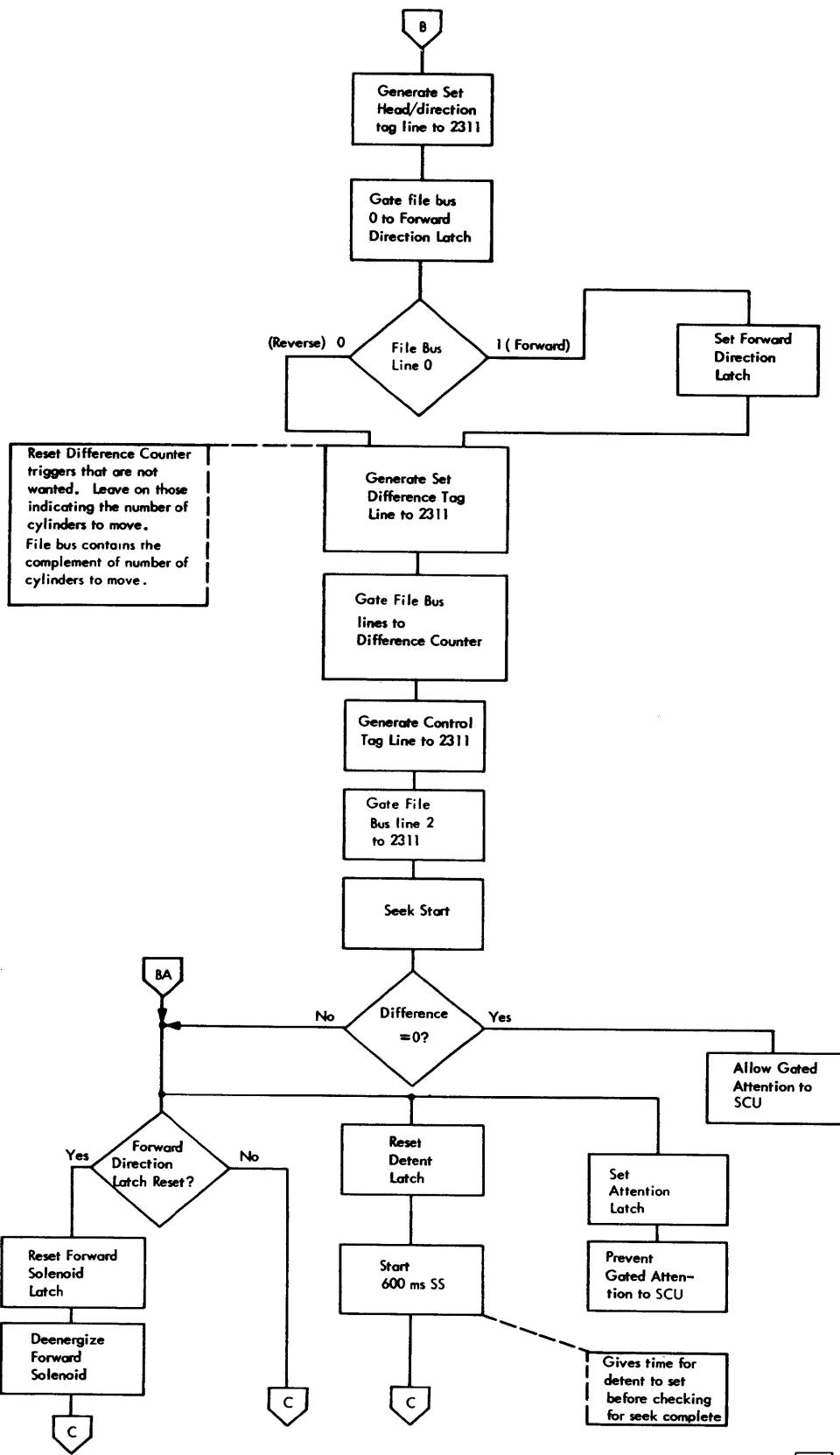


Figure 3-5b. Programmed Seek Flow Chart

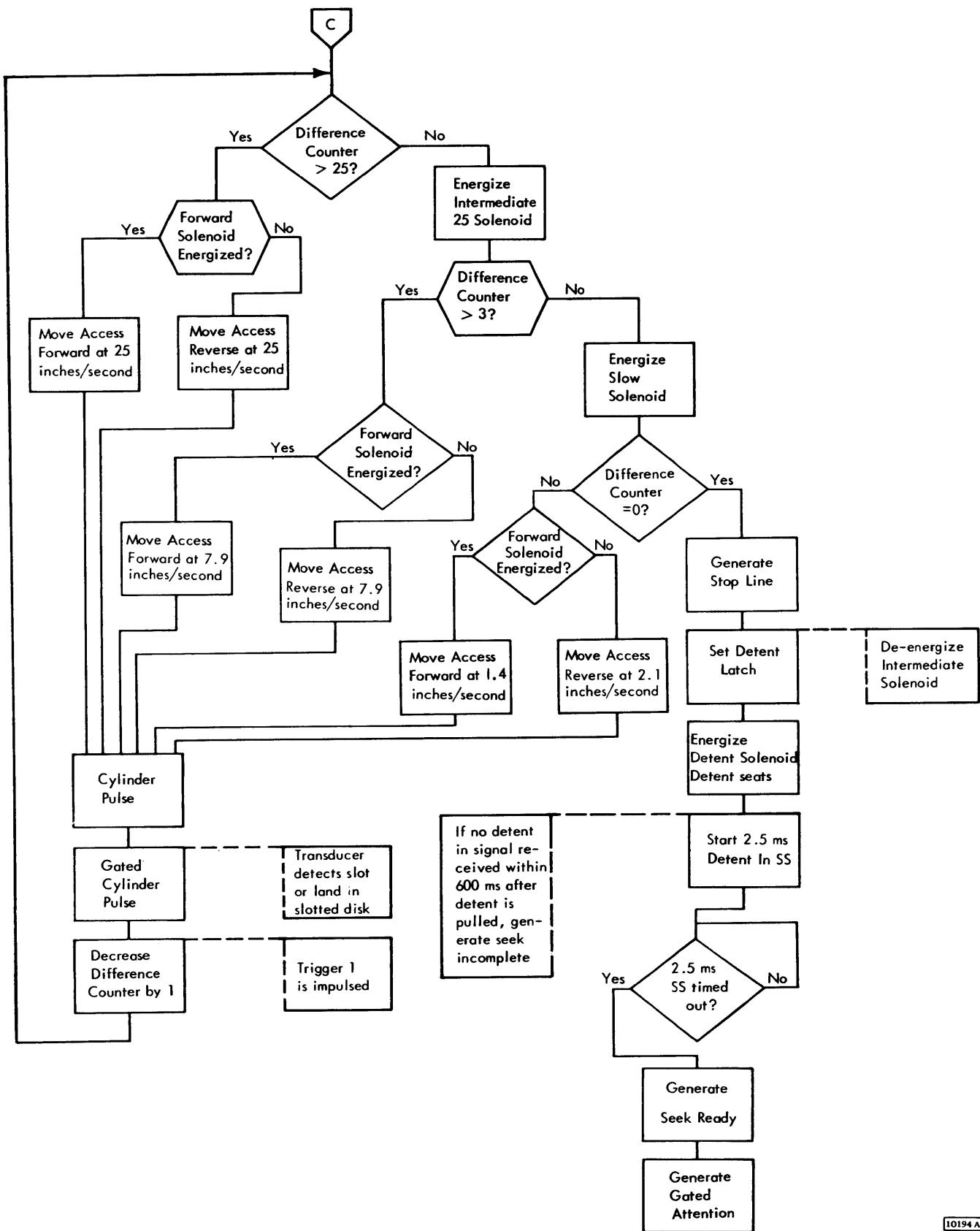


Figure 3-5c. Programmed Seek Flow Chart

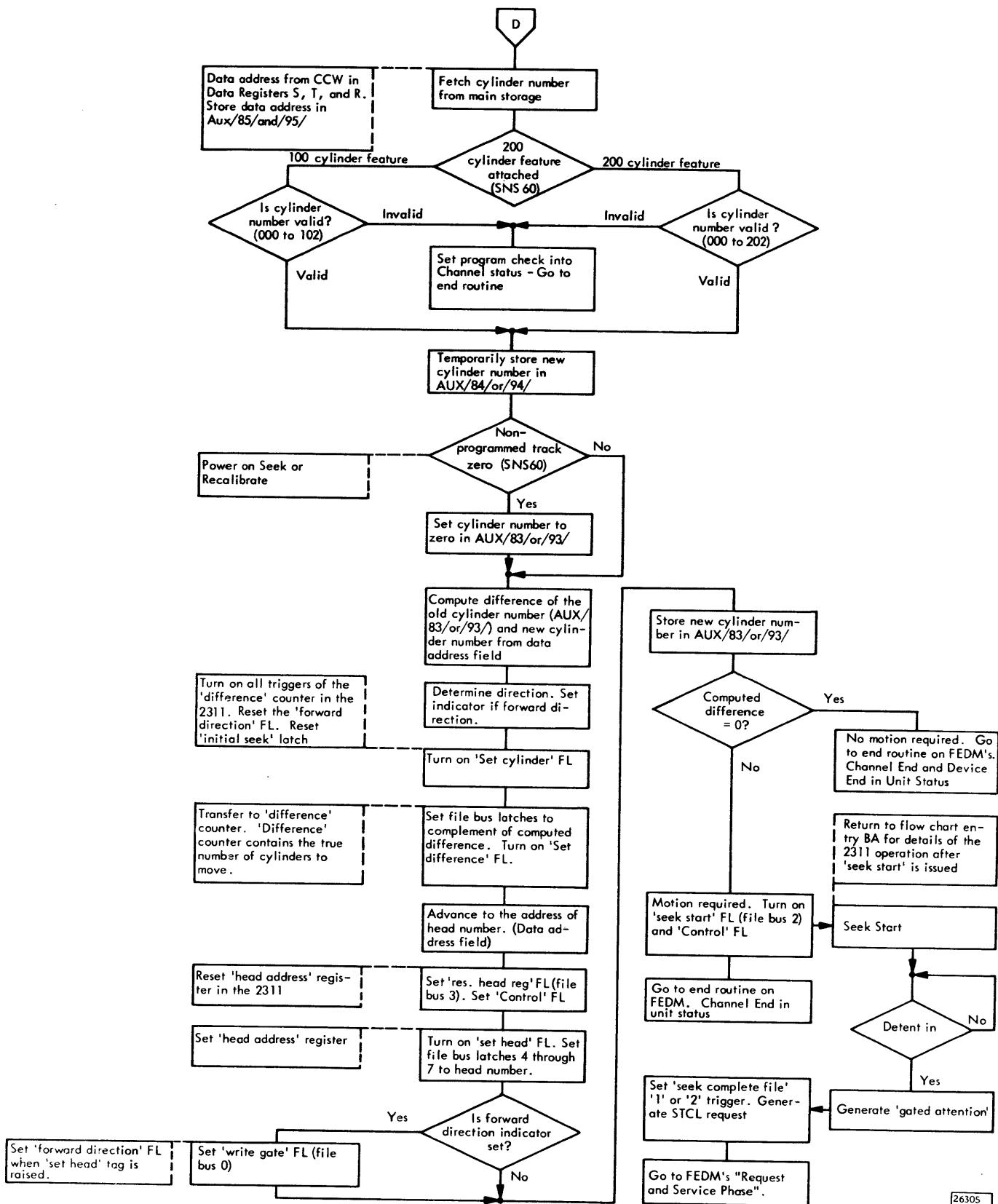


Figure 3-5d. Programmed Seek Flow Chart

2841 [see the section on "Programmed Recalibrate Command (restore)"]. In either of the preceding cases, the 'initial seek' latch is on since a 'selected set cylinder' impulse has not yet occurred, on the first programmed seek, to turn it off (FD026). If the 'initial seek' latch is still set, the gate controlling the CAR outputs to the 2841 (FD026) is not developed. Thus, the 2841 determines that the access is at track 000.

If the 'initial seek' latch is not on, 'module select' immediately gates the present cylinder location of the access to the 2841.

Following the readout of the present access location, the 'head address register' is reset by a 'control' tag line so that all triggers are off.

A 'set head/direction' tag line (Figure 3-5a), together with the appropriate signals on the file bus, sets the head address register to cause a head to be addressed.

The cylinder address to be used on the seek operation is transferred to the CAR by a 'set cylinder' tag line. All of the difference counter triggers are set on at the same time. The 255's complement of the number of cylinders the access is to move is later turned off by signals from the 2841. The 'forward direction' latch is also reset off at this time.

The 'set head/direction' tag line comes up for the second time. The 'file bus 0' line is gated to the 'forward direction' latch. The 'forward direction' latch is set on if the 'file bus 0' line is up, or left off (reverse) if the 'file bus 0' line is down.

A 'set difference' tag line gates 'file bus' lines (255's complement of the number of cylinders) to the difference counter to reset the triggers which are not wanted, leaving on only those which indicate the number of cylinders to move.

A 'seek start' is signalled by use of a 'control' tag line and 'file bus 2' (Figure 3-5b). If the 'forward direction' latch was not previously set on by the 'file bus 0', the 'forward solenoid' latch is reset off to cause reverse motion; otherwise, the 'forward solenoid' latch remains on and forward motion results. The 'detent' latch is reset by the 'seek start' impulse.

Each 'gated cylinder pulse' developed by the sensing of slots and lands in the slotted disk causes the difference counter to step down. The access speed shifts (Figure 3-5c) at 25 cylinders and at three cylinders from the addressed location. Finally, just before the addressed cylinder, a 'stop' line is developed by the difference counter decode (FD040), and the 'detent' latch (FD050) turns on to cause the

carriage to stop. A 2.5 ms SS delays the development of a 'seek ready' signal (FD053) to allow time for the read/write heads to stop vibrating before they are used.

Circuit Objectives (Figure 3-6)

System Diagram
FD026

Signal Present Cylinder Location (True Form): 'Module select' ANDs with '[not] initial seek' latch to gate the present cylinder location to the 2841. 'Initial seek' latch prevents gate-out of the CAR latches if the access is at cylinder 000 from a power-on seek or recalibrate (restore) operation. The 2841 now contains both the present cylinder location and the newly addressed cylinder location.

Reset Head Address Register to Zero: FD060
The reset is developed by 'selected control' tag line and 'file bus 3'.

Set Head Address Register If Required: FD060
The head address register triggers were previously turned off, causing 'head 0' to be addressed. The 'set head/direction' tag line and 'module select' AND to gate the 'file bus 4-7' lines, and turn on the appropriate head address register triggers.

Set New Address in CAR (True Form): FD030
'Module select' and 'set cylinder' tag gate 'file bus' lines to set the appropriate CAR latches.

Reset Initial Seek Latch: The 'selected set cylinder' line resets the 'initial seek' latch if it is still on after a preceding power-on seek or recalibrate (restore) seek. The 'initial seek' latch remains off after the first programmed seek as long as 2311 power is not interrupted and no 'recalibrate' (restore) seek is initiated.

Reset Forward Direction Latch: The 'selected set cylinder' signal turns off the latch. FD050

Set All Difference Counter Triggers On:
A module selected set cylinder tag turns on all triggers.

Set Forward Direction Latch: The 'set head/direction' tag line comes up for the second time and ANDS with 'file bus 0'. If the 'file bus 0' line is up (logical 1), the 'selected set head' line turns on the 'forward direction' latch. If the 'file

System Diagram
FD040

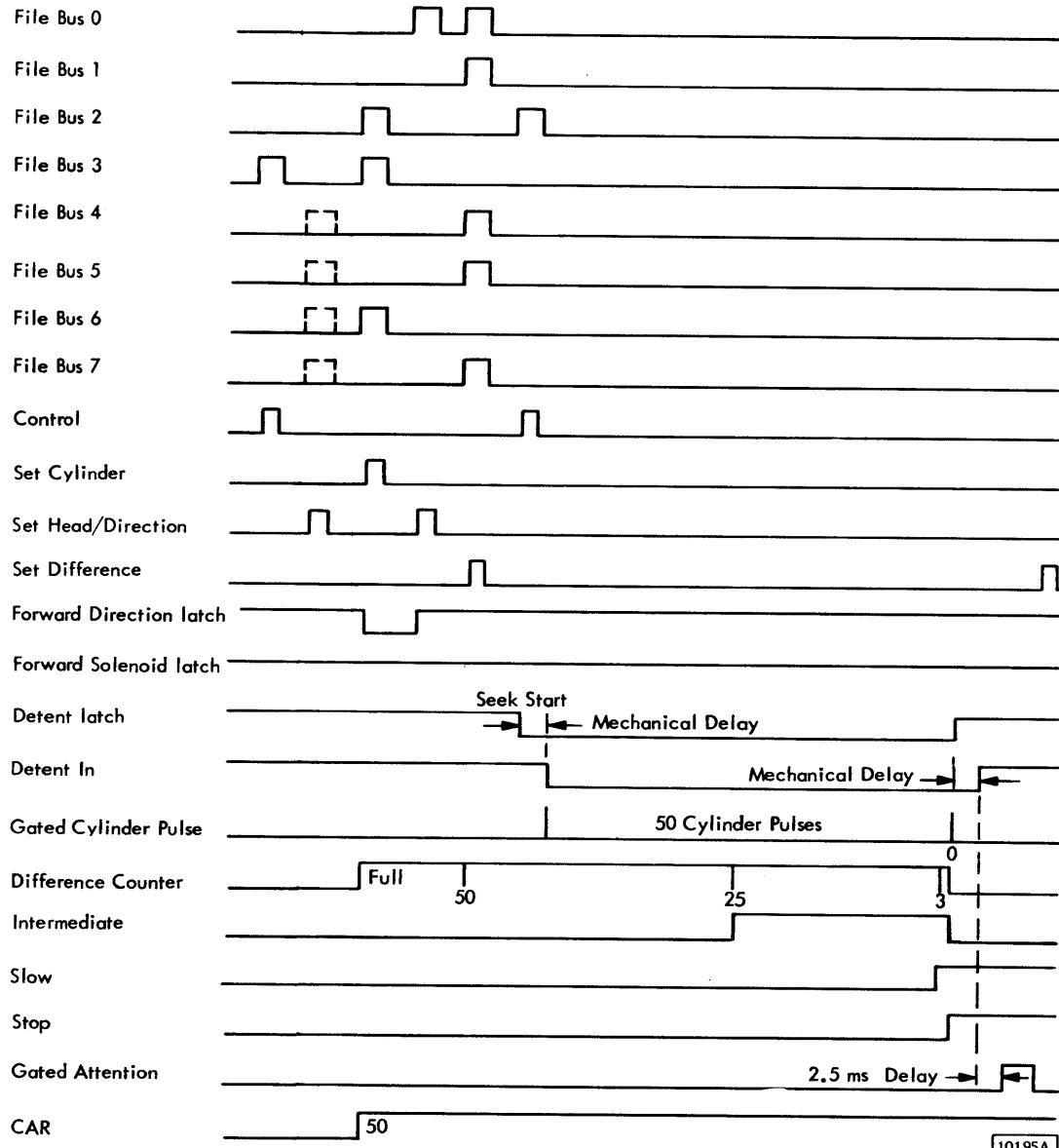
bus 0' line is down (logical 0), the 'forward direction' latch remains off.

System Diagram

FD050

Set Forward Solenoid Latch and Energize Forward Solenoid: The 'forward solenoid' latch was turned on when the last detent occurred. If the 'forward direction' latch is on (forward seek), the 'selected seek start' signal cannot turn off the 'forward

FD050



10195A

Figure 3-6. Programmed 50 Cylinder Forward Seek Model 1 (2841 SCU)

<u>System Diagram</u>		<u>System Diagram</u>
solenoid' latch. This condition results in a forward seek.		
<u>Reset Unwanted Triggers in the Difference Counter:</u> The 'module selected' line and the 'set difference' tag gates the 'file bus' lines (lines up are the 255's complement of the number of cylinders to be moved) to turn off unwanted triggers in the difference counter. This results in the difference counter being set to the true value of the number of cylinders to be moved.	FD030 FD040	[not] heads retracted or restore' and 'first seek completed' latch signals, the slow solenoid is operated.
<u>Generate Seek Start to Pull Detent:</u> The 'selected control' line and 'file bus 2' cause a 'selected seek start' signal. The 'selected seek start' signal and '[not] stop' signal AND together to turn off the 'detent' latch. This de-energizes the detent solenoid and the detent pulls out.	FD020	<u>Stop Carriage When Difference Counter Equals Zero:</u> When all difference counter triggers are off, a 'stop' signal is developed. The same 'cylinder pulse' which turns off the last difference counter trigger also times the set of the 'detent' latch. With the 'slow' and 'intermediate' lines up, the 'stop' signal turns on the 'detent' latch, which in turn energizes the detent solenoid.
<u>Set Attention Latch:</u> The 'selected seek start' signal turns on the 'attention' latch.	FD050	<u>Generate Seek Ready:</u> The 'detent in' signal from the transducer, delayed 2.5 ms (4 μ sec delay card prevents a signal sliver), causes the development of the 'seek ready' signal.
<u>Move at Fast Speed, Forward or Reverse:</u> With the detent pulled and more than 25 cylinders to go, access moves at speed since neither slow nor intermediate line is up.	FD050	<u>Generate Ready Signal to the 2841:</u> The 'seek ready' line is interrogated by the 'module select' line from the 2841 to determine if the module is ready (file ready).
<u>Decrease Value in Difference Counter:</u> The 'gated cylinder pulse' is developed with each 'cylinder pulse' because the 'detent' latch is off and the 'first seek completed' latch is set. The difference counter decreases by one with each 'gated cylinder pulse'. (Refer to the Functional Units chapter.)	FD053	<u>Generate Gated Attention Pulse to the 2841:</u> The 'attention' latch was turned on by the 'selected seek start' pulse at the beginning of the seek operation. When the detent is set at the end of the seek operation, the 'attention' latch and the 'seek ready' signal develop the 'gated attention' signal to the 2841.
<u>Slow to 7.9 Inches/Second:</u> With the 'difference counter' at a value of 25 or less, the 'intermediate' signal is developed. With '[not] detent' latch and 'first seek completed' latch signals, the intermediate solenoid is operated.	FD040	PROGRAMMED FORWARD OR REVERSE SEEK, 2311 MODELS 11 OR 12
<u>Slow to 1.4 Inches/Second (2.1 Inches/Second if Reverse Motion):</u> With the difference counter at a value of 3 or less, the 'slow at 3' signal is developed. With	FD040 FD050 FD105 FD040	<ul style="list-style-type: none"> ● Select the 2311 (Figures 3-5a, 3-5b, 3-5c, and 3-5d). ● Fetch cylinder number from main storage. ● Determine if cylinder number is valid and store in auxiliary (AUX) storage. ● Compute number of cylinders to move. ● Determine direction of move. ● Transfer the computed number of cylinders to move to the difference counter.

- Reset and set head address register and 'direction' FL.
- Pull the detent and begin either forward or reverse motion.
- Slow to 7.9 inches/second when the access is 25 cylinders from the addressed cylinder.
- Slow to 1.4 inches/second (2.1 inches/second if reverse motion) when the access is three cylinders from the addressed cylinder.
- Stop when the difference counter indicates that the access is at the addressed cylinder (All triggers are off.)
- Signal 'gated attention' to the System/360 Model 20 Storage Control (STCL).

Description

The 2311 is first selected by bringing up the appropriate 'module select' line in the STCL. Since the STCL must compute how many cylinders the access must move from its present location, a means must be provided to determine if the access is at cylinder 000 or some other location (Figure 3-5d). The access is at cylinder 000 if a power on seek has occurred or a 'recalibrate' (restore) was signalled by the STCL. Refer to "Programmed Recalibrate Command (Restore)" for additional information. In either of the preceding cases, the 'initial seek' latch is on since a 'selected set cylinder' impulse has not yet occurred, on the first programmed seek, to turn it off (FD026). If the 'initial seek' latch is still on, the line 'cyl 000' (FD057) is active, causing the STCL to store 000 in AUX/83/ or /93/. Thus, the STCL uses 000 in the computation of direction and amount of cylinder movement required.

If the 'initial seek' latch is not on, the line 'cyl 000' is not active, and the old cylinder number in AUX/83/ or /93/ is used.

The direction of movement is determined during the computation of the amount of movement required. If forward movement is required, the 'forward direction' indicator is set for later use.

At this time, the 'set cylinder' flip-latch (FL) in the STCL is turned on. This line becoming active causes three things to happen: the 'forward direction' FL in the 2311 is reset off, the 'initial seek' latch is turned off, if on, and all triggers in the 'difference counter' are turned on.

The 'set difference' FL is now turned on in the STCL. The 'file bus 0-7' lines contain the computed 255's complement of the number of cylinders to be moved. Each active 'file bus 0-7' line turns off its corresponding difference counter trigger; that is, 'file bus 7' active turns off 'difference counter trigger one', and so on. Because the number of active 'file bus' lines is the complement of the number of cylinders to be moved, the triggers that are not turned off represent the true number of cylinders to be moved (FD040).

The 'res. head reg' FL is turned on in the STCL, activating 'file bus 3'. The 'control' FL is turned on, gating a reset (off) to all the head address register (HAR) triggers (FD060).

Immediately following the reset of HAR, the 'set head' FL in the STCL is turned on. The 'file bus 4-7' lines contain the true head number, causing the appropriate 'head address' register triggers to turn on.

At the same time as HAR is being set, the 'forward direction' indicator, if on, causes 'file bus 0' to be active. The 'set head' line, being active, causes the 'forward direction' latch in the 2311 to be turned on. If the 'forward direction' indicator is off, 'file bus 0' is inactive, and the 'forward direction' latch remains off (reverse).

The STCL stores the new cylinder number in AUX/83/ or /93/ at this time for use in computing the movement required on a future seek.

If the computed movement required is zero, the operation terminates at this time and the STCL proceeds into the end routine.

For purposes of explaining the operation on a seek, assume that the computed movement required is 50 cylinders.

The 'seek start' FL is turned on (activating 'file bus 2') by the STCL. The 'control' FL is then turned on, and the two active levels AND in the 2311 to produce the 'seek start' line. If the 'forward direction' latch was previously left off, the 'forward solenoid' latch will now be turned off, and reverse access movement will result. Conversely, if the 'forward direction' latch was turned on, the 'forward solenoid' latch is not affected, and forward movement of the access occurs.

The 'detent' latch is also reset by the 'seek start' signal. The 'detent' solenoid is de-energized, causing full pressure to be applied to the detent actuator, and the detent pulls out of the detent gear.

Full system pressure is now applied to the access piston. The intermediate and slow solenoids have not been energized; therefore, movement is at fast speed (direction was determined above).

As the access moves, 'gated cylinder pulses', developed by the sensing of slots and lands in the slotted disk, cause the difference counter to step down. The access speed shifts (Figure 3-5c) at 25 cylinders and at three cylinders from the addressed cylinder. Just before the addressed cylinder, a 'stop' line is developed by the difference counter decode (FD040), and the 'detent' latch (FD050) turns on to cause the carriage to stop. A 2.5 ms SS delays the development of 'seek ready' and 'gated attention' lines to allow time for the read/write heads to stop vibrating before they are used.

The 'gated attention' line is used by the STCL to turn on the 'seek complete file 1 (or 2)' trigger and generate the 'STCL request'. The microprogram then continues with the "Request and Service Phase" as shown in the FEDM's.

Circuit Objectives (Figure 3-6a)

Determine if Access is at Cylinder 000:

If the 'initial seek' latch is on from a previous power-on seek or a 'recalibrate' (restore) command, the 'seek ready' line ANDing with the 'initial seek' line causes the 'cyl 000' line to be active to the STCL.

Reset Initial Seek Latch: The 'selected set cylinder' line resets the 'initial seek' latch if it is still on after a preceding 'power on' seek or 'recalibrate' (restore) seek. The 'initial seek' latch remains off after the first programmed seek as long as 2311 power is not interrupted and no 'recalibrate' (restore) seek is initiated.

Reset Forward Direction Latch: The 'selected set cylinder' signal turns off the latch.

Set All Difference Counter Triggers On: A module selected 'set cylinder' tag turns on all triggers.

Reset Unwanted Triggers in the Difference Counter: The 'module selected' line and the 'set difference' tag gates the file bus lines (lines up are the 255's complement of the number of cylinders to be moved) to turn off unwanted triggers

System
Diagram
FD026

FD057

FD026

FD050

FD040

FD030
FD040

in the difference counter. This results in the difference counter being set to the true value of the number of cylinders to be moved.

Reset Head Address Register to Zero:
The reset is developed by 'selected control' tag line and 'file bus 3'.

Set Head Address Register If Required:
The head address register triggers were previously turned off, causing head 0 to be addressed. The 'set head/direction' tag line and 'module select' AND to gate the 'file bus 4-7' lines, and turn on the appropriate head address register triggers.

Set Forward Direction Latch: The 'set head/direction' tag line also ANDs with 'file bus 0'. If the 'file bus 0' line is up (logical 1), the 'selected set head/direction' line turns on the 'forward direction' latch. If the 'file bus 0' line is down (logical 0), the 'forward direction' latch remains off.

Generate Seek Start to Pull Detent: The 'selected control' line and 'file bus 2' cause a 'selected seek start' signal. The 'selected seek start' signal and '[not] stop' signal AND together to turn off the 'detent' latch. This de-energizes the detent solenoid and the detent pulls out.

Set Forward Solenoid Latch and Energize Forward Solenoid: The 'forward solenoid' latch was turned on when the last detent occurred. If the 'forward direction' latch is on (forward seek), the 'selected seek start' signal cannot turn off the 'forward solenoid' latch. This results in a forward seek.

Set Attention Latch: The 'selected seek start' signal turns on the 'attention' latch.

Move at Fast Speed, Forward or Reverse:
With the detent pulled and more than 25 cylinders to go, access moves at fast speed since neither slow nor intermediate line is up.

System
Diagram

FD060

FD060

FD050

FD020

FD050

FD050

FD053

FD050

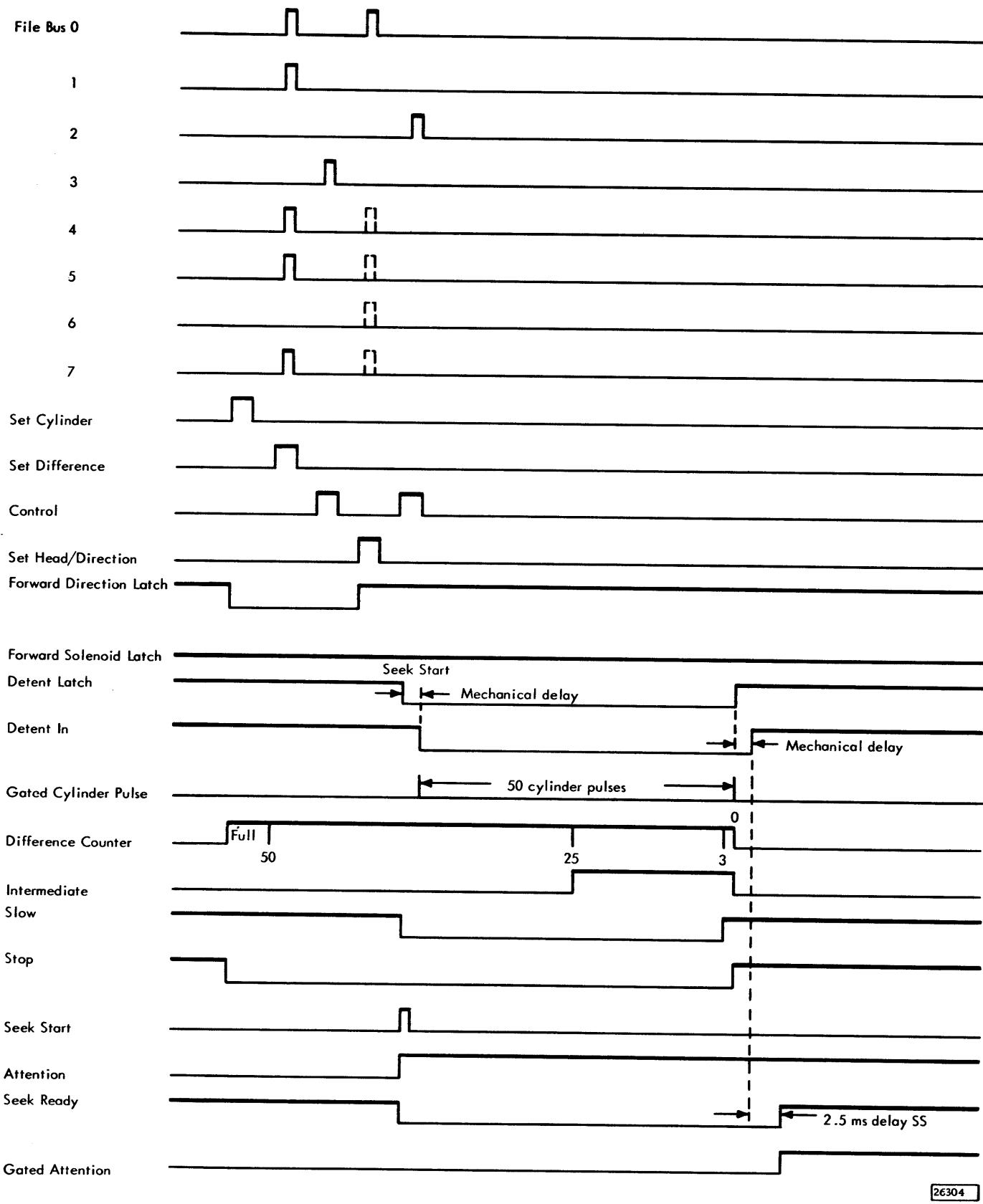


Figure 3-6a. Programmed 50 Cylinder Forward Seek, Model 11 or 12 (Model 20 CPU)

Decrease Value in Difference Counter: The 'gated cylinder pulse' is developed with each 'cylinder pulse' because the 'detent' latch is off and the 'first seek completed' latch is set. The difference counter decreases by one with each 'gated cylinder pulse'. (Refer to the Functional Units chapter.)

Slow to 7.9 Inches/Second: With the difference counter at a value of 25 or less, the 'intermediate' signal is developed. This signal ANDs with '[not] detent' latch and 'first seek completed' latch signals to operate the intermediate solenoid.

Slow to 1.4 Inches/Second (2.1 Inches/Second If Reverse Motion): With the difference counter at a value of 3 or less, the 'slow at 3' signal is developed. This signal ANDs with '[not] heads retracted or restore' and 'first seek completed' latch signals to operate the slow solenoid.

Stop Carriage When Difference Counter Equals Zero: When all difference counter triggers are off, a 'stop' signal is developed. The same 'cylinder pulse' which turns off the last difference counter trigger also times the set of the 'detent' latch. With the 'slow' and 'intermediate' lines up, the 'stop' signal turns on the 'detent' latch, which in turn energizes the detent solenoid.

Generate Seek Ready: The 'detent in' signal from the transducer, delayed 2.5 ms (4 μ sec delay card prevents a signal sliver), causes the development of the 'seek ready' signal.

Generate Ready Signal to the STCL: The 'seek ready' line is interrogated by the 'module select' line from the STCL to determine if the module is ready (file ready).

Generate Gated Attention Pulse to the STCL: The 'attention' latch was turned on by the 'selected seek start' pulse at the beginning of the seek operation. When the detent is set at the end of the seek operation, the 'attention' latch and the 'seek ready' signal develop the 'gated attention' signal to the STCL.

Start
Diagram
FD053

FD040

FD040

FD050
FD105

FD040

FD050

FD105

FD040

FD050

FD105

FD053

FD090

FD053

PROGRAMMED RECALIBRATE COMMAND (RE-STORE)

- If cylinder reference is lost because of programming or machine error, the program can issue a 'recalibrate' command.
- The 'recalibrate' command causes the access to move at fast reverse speed to hydraulic home and then move at slow speed to cylinder 000.
- The 'seek ready', 'file ready', and 'gated attention' signals are generated in the same manner as on normal programmed seeks.
- The 'recalibrate' command activates the 'restore' line in the 2311.

Description

If cylinder reference is lost because of a programming problem or machine error such as a 'seek incomplete', a 'recalibrate' command can be issued from the CPU and sent to the SCU. The SCU, through microprogramming, then activates the 'control' signal and 'file bus 6' signal which AND together in the 2311 and produce the 'restore' signal (Figure 3-2). The 'restore' signal causes the access to move to hydraulic home and then to cylinder 000. The 'restore' signal is active for the duration of the 'control' tag signal (15 ms or more). The 'restore' signal conditions the circuitry for fast reverse motion and sets the various controls to the same condition they would be in at the end of a power on seek. Following the fast reverse motion, the carriage moves forward at slow speed to cylinder 000.

Circuit Objectives (Figure 3-7)

Develop 'Restore' Signal: "Control" tag line and 'file bus 6' develop 'restore' signal if the unit is selected and not unsafe (FD021).

Reset of Controls: The following controls are affected by the momentary 'restore' signal:

1. 'Intermediate' and 'slow' lines are deactivated. (FD050).
2. 'Detent' latch turned off, deactivating the detent solenoid (FD050).
3. 'Initial seek' latch is turned on, used to reset CAR to 000 (FD026). The 'cylinder 000' line on FD057 signals the Model 20 that the access is at 000.

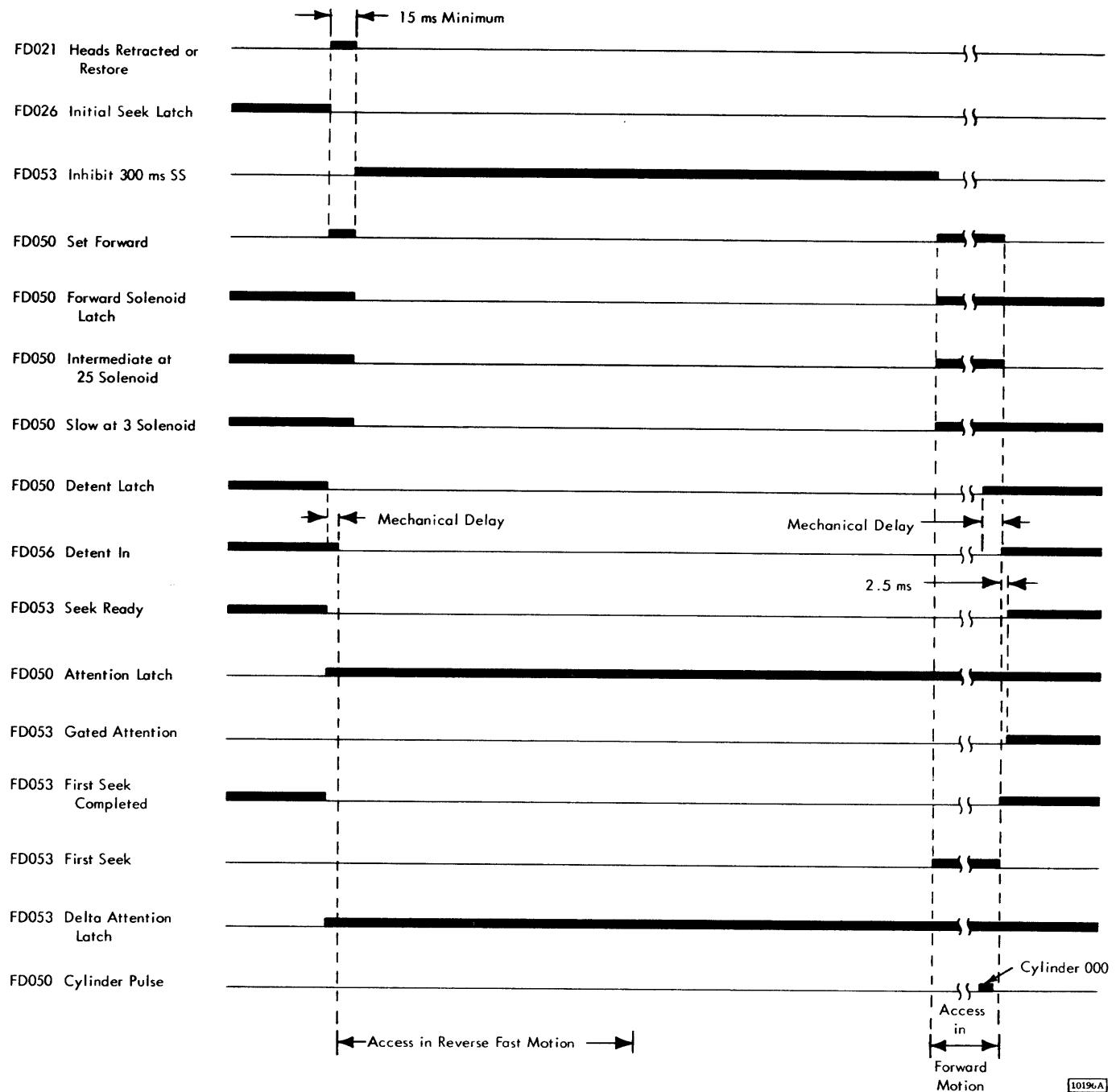


Figure 3-7. Timing for Recalibrate (Restore)

4. 'Delta attention' and 'Attention' latch turned on (FD053).
5. 'First seek completed' latch is turned off (FD053).
6. HAR triggers are reset off (FD060).
7. The ready light is turned off.

Start the 300 ms SS: The end of the 15 ms control pulse from the SCU drops the 'restore' signal and allows the 'restore' and 'heads retracted or restore' lines to return to their inactive condition. The return of 'heads retracted or restore' to the inactive state causes the 300 ms SS (inhibit) to start timing (FD053).

Reset Forward Solenoid Latch and Move Backward at Fast Speed: As previously noted, the 'detent' latch was turned off, deactivating the detent solenoid. The 'inhibit' line becoming active resets the 'forward solenoid' latch, which in turn deactivates the forward solenoid (FD050). With the intermediate and slow solenoids deactivated, the access moves backward at fast speed to hydraulic home. The access then rests at hydraulic home, until the 300 ms SS (inhibit) times out.

Move Forward at Slow Speed: When the 300 ms SS times out, the 'set forward' line is activated, because the 'first seek completed' latch is off (FD053). The 'set forward' line turns on the 'forward solenoid' latch (FD050). The 'forward solenoid' latch activates the forward solenoid. '[Not] inhibit' and '[not] first seek completed' AND together to activate the 'first seek' line (FD053). The 'first seek' line activates the slow and intermediate solenoids (FD050). With the forward, slow, and intermediate solenoids activated, the access moves forward at slow speed.

Stop at Cylinder 000: The 'first seek' line, (slow or intermediate) line and the 'cylinder pulse' line AND together to turn on the 'detent' latch. The 'detent' latch activates the detent solenoid and, after a slight mechanical delay, the detent seats into the detent wheel, stopping further movement of the carriage (FD050).

The 'detent' latch being on also deactivates the intermediate solenoid (FD050).

Generate 'Seek Ready': When the detent transducer signals that the detent is in, the 'detent in' line turns on 'first seek completed' (FD053). After the 2.5 ms SS times out, the 'seek ready' line is activated (FD053).

'Ready' and 'gated attention' are generated in the same manner as on a normal seek.

SEEK INCOMPLETE CIRCUIT

During a 'seek' or 'restore' operation, if the 'detent in' line is not activated within 600 ms after the detent is pulled, the 'seek incomplete' latch is turned on.

Refer to the following diagram, which is an ALD representation from FD053 logic blocks 1-7G. (See Figure 3-8).

At the beginning of the 'seek' or 'restore' operation, the detent is pulled to allow the access mechanism to move. The detent coming out of the detent gear is sensed by the detent transducer. The 'detent in' line is de-activated, causing the input pin G13 on the AND logic block 1G to be active. The other input on the AND logic block 1G is already active; therefore the AND circuit output becomes active. The AND circuit output triggers the 600 ms TD. If the 600 ms TD is allowed to time out, its output goes plus and sets the 'seek incomplete' latch. The 'seek incomplete' latch should not turn on unless a mechanical problem, or incorrect programming, occurs.

The 'seek incomplete' latch is prevented from turning on, in normal operation, in the following manner. The detent is seated in a maximum time of approximately 135 ms. The detent seating in the detent gear is sensed by the detent transducer. The detent transducer circuit causes the 'detent in' line to become active. The 'detent in' line causes the input pin G13 on the AND logic block 1G to be inactive, blocking the AND circuit. The AND circuit output goes to a plus level, preventing the 600 ms TD from timing out. The time-delay output, therefore, never goes plus and 'seek incomplete' is not turned on.

READ/WRITE OPERATIONS

- The 2311 uses double-frequency horizontal NRZ recording method.
- The conventional horizontal recording device is a ring with a gap and a coil wound at some point on the ring.
- During a write operation, a bit is recorded when the flux direction in the ring is reversed by rapidly reversing the current in the coil.

-HEADS RETRACTED OR RESTORE

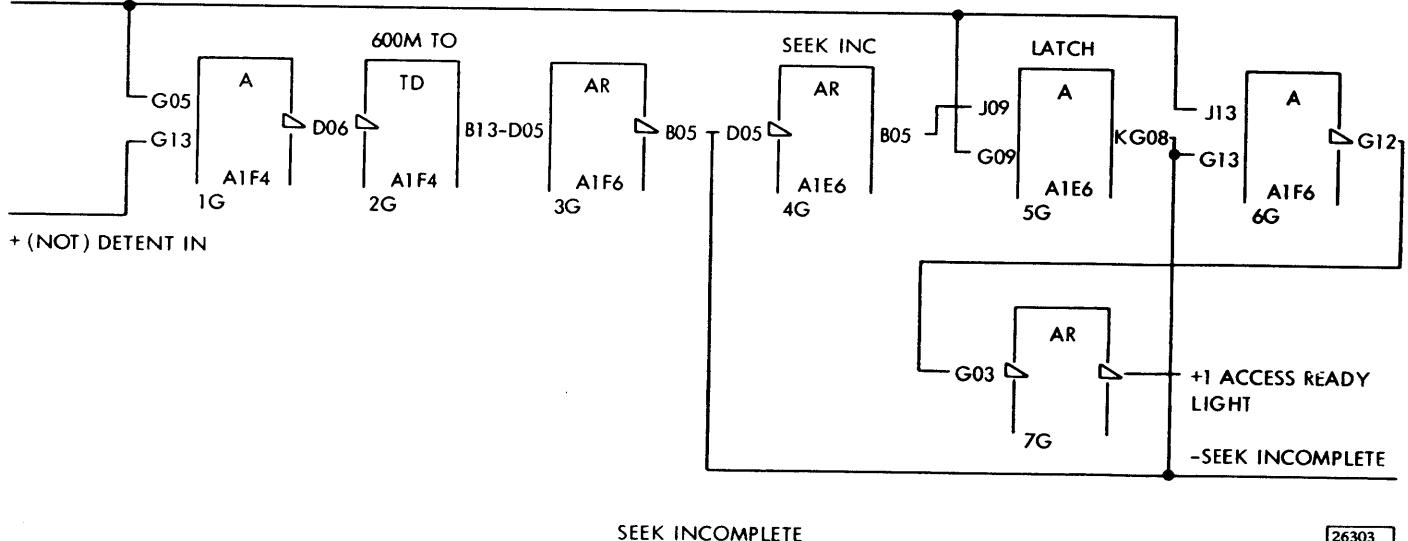


Figure 3-8. Seek Incomplete -- ALD Representation

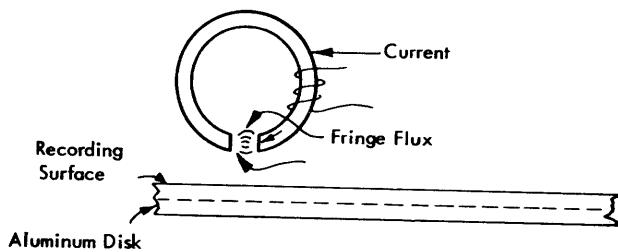
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- During a read operation, a bit is sensed when the flux direction in the ring is changed as a result of a flux reversal on the disk surface.

The IBM 2311 Disk Storage unit uses the double-frequency horizontal non-return-to-zero method of magnetic recording. Each transition of magnetization from plus to minus or minus to plus polarity represents the storage of a bit.

Double frequency is the term given to the recording system that injects a clock bit at the beginning of each bit cell time, thereby doubling the frequency of recorded bits. The conventional horizontal recording device is a ring with a gap and a coil wound at some point on the ring. When current flows through the coil, the flux induced in the ring fringes at the gap (Figure 3-9). As a magnetic recording surface passes by the gap, the fringe flux magnetizes the surface in a predominantly horizontal direction.

During a write operation, a bit is recorded when the flux direction in the ring is reversed. This reversal is accomplished by rapidly reversing the direction of the current in the coil. The fringe flux is reversed in the gap and hence the portion of the flux flowing through the recording medium is reversed. If the flux reversal is considered instantaneous in comparison to the motion of the



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Figure 3-9. Basic Ring Head

recording surface, and the gap is observed at the moment of reversal, it can be seen that the portion of the surface that just passed the gap is magnetized in one horizontal direction while the portion directly under the gap is magnetized in the opposite direction. Between these two areas, the flux must reverse 180°; this recorded flux reversal represents a bit (Figure 3-10).

During a read operation, the gap first passes over an area that is magnetized in one horizontal direction, and a constant flux flows through the ring and the coil. The coil registers no output voltage. However, when the recorded bit (180° horizontal

flux reversal) passes the gap, the flux flowing through the ring and coil must also go through a 180° reversal. This means that the coil sees a change in flux which results in a voltage output pulse (Figures 3-11 and 3-12).

READ/WRITE HEAD

- The 2311 read/write head is a four-terminal device containing three coils.
- The 2311 writes a wide band, then "tunnel" erases the recorded data to leave a narrow band.

Description

The 2311 read/write head is a four-terminal device containing three coils (Figure 3-13). One coil is used exclusively for magnetically erasing data from the disk. The remaining two coils are connected in series (center tapped) and are used for reading and writing on the disk surfaces.

The 2311 head is designed with the read/write core ahead of a split erase core (Figure 3-14). This unique design (called tunnel erase) allows the 2311 to write a band of data 0.008" wide then immediately erase it to 0.005" wide. The difference in erase and write width allows for minor deviations in head positioning during subsequent read operations.

The current through the write coil erases the old data as new data is recorded.

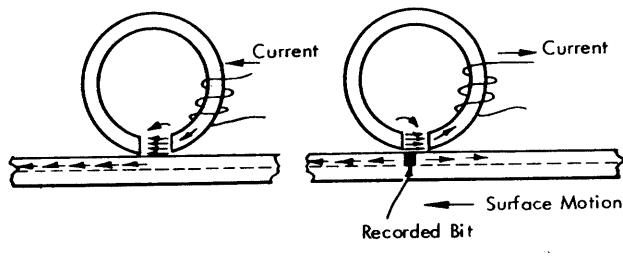


Figure 3-10. Horizontal NRZI Recording

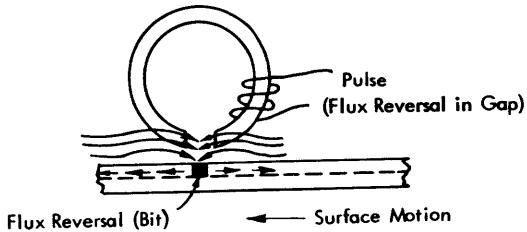
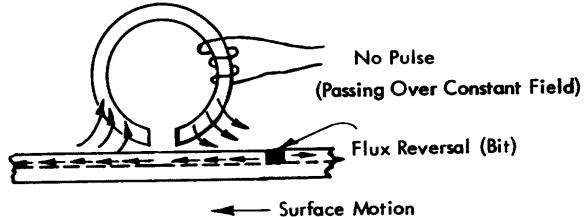


Figure 3-11. Reading Horizontal Fields with Ring Head

WRITE OPERATION

Basic Operation

- A bit cell time consists of two SCU oscillator pulse periods or 800 nanoseconds.
- A clock pulse is always written at the beginning of each bit cell time or every 800 nanoseconds.
- The clock pulses, written at a 1.25 megabit/sec rate and read at the same rate, make the amplifier self-stabilizing.
- A logical 1 bit is represented by a clock pulse at the beginning and a data pulse at the middle of a bit cell time. Pulses are 400 ns apart; bit frequency is 2.5 megabits/sec.
- A logical 0 bit is represented by a clock pulse only; therefore, the pulses are 800 ns apart and bit frequency is 1.25 megabits/sec.

Write Circuits

- Write data from the SCU is converted to a -L level by the line receiver circuit (Figure 3-15).

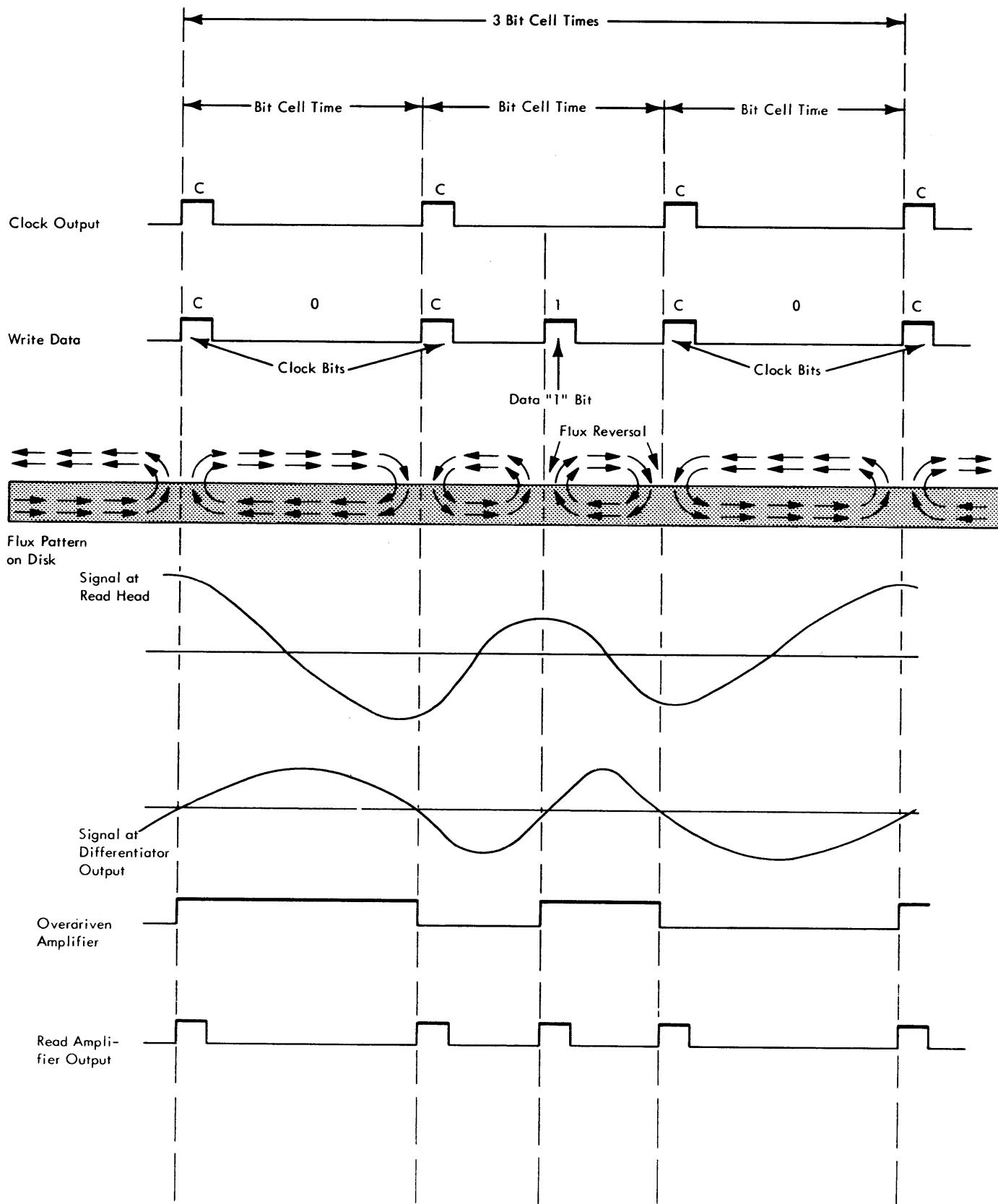


Figure 3-12. Double Frequency Recording Flux and Pulse Relationship

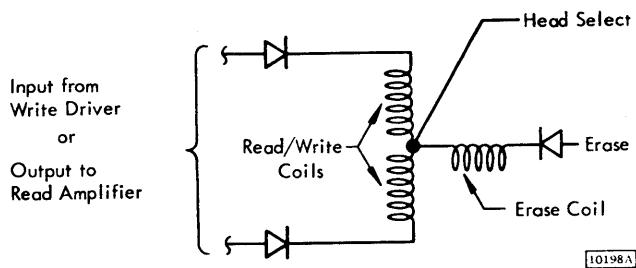
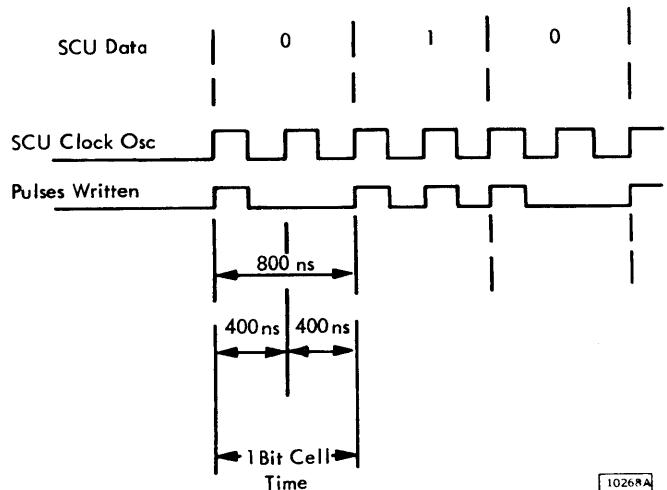


Figure 3-13. Read/Write Head Circuit

- The 'write gate' in the selected module allows a write current of 34 ma to flow to the write driver circuit.



- The binary-connected 'write trigger' flips with each pulse on the 'write data' line.
- The level set circuit output alternately drives one or the other of the write driver circuits.

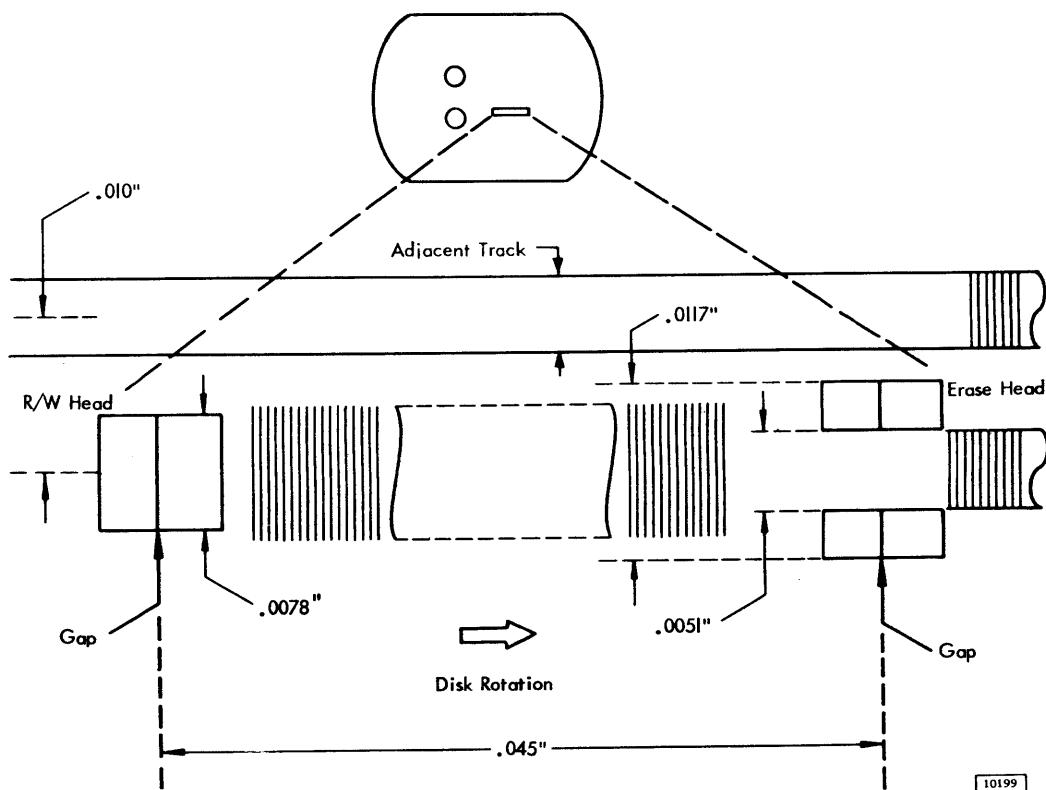


Figure 3-14. Magnetic Head-to-Disk Relationship

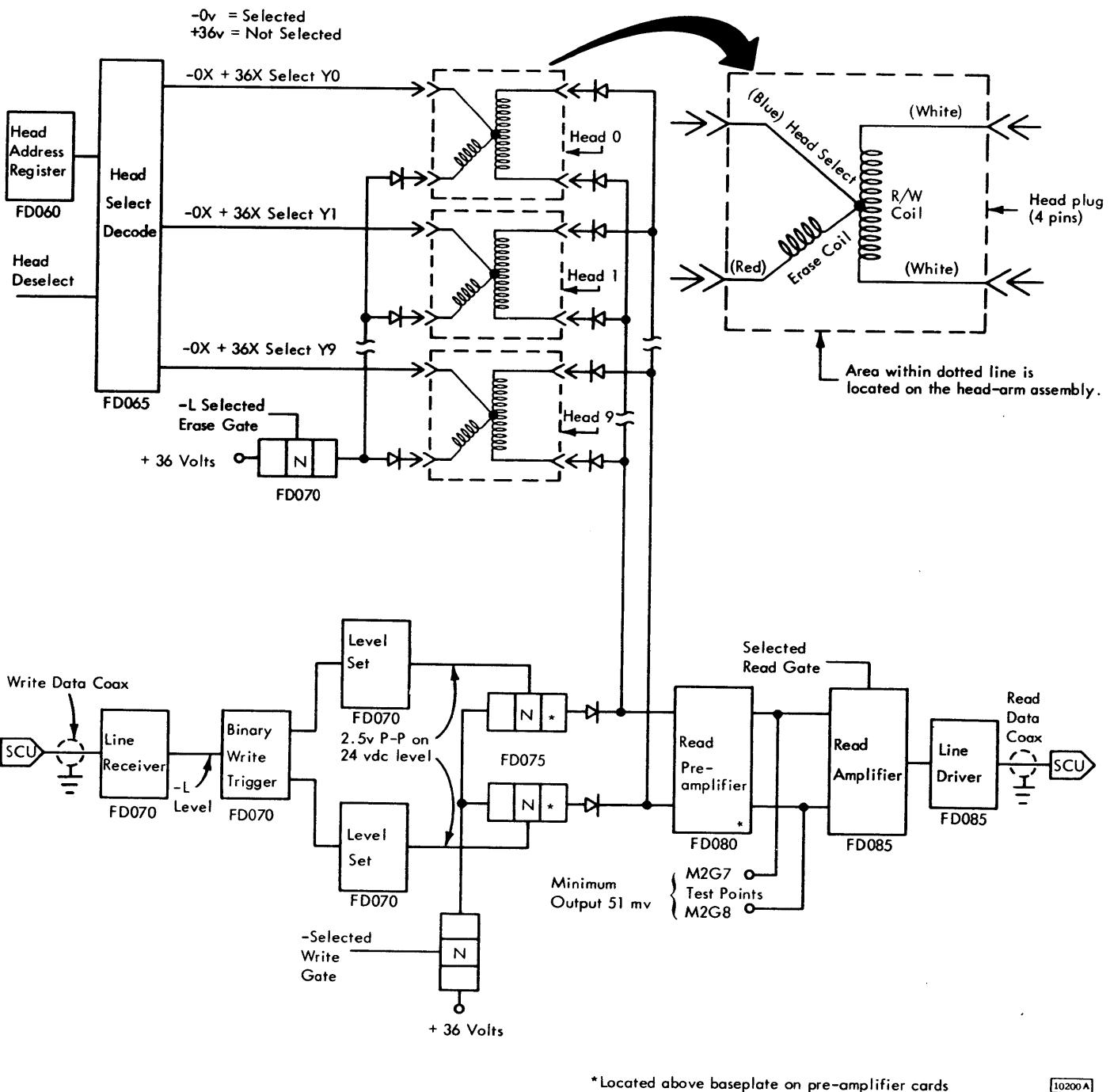


Figure 3-15. Write Circuits

- If the head is selected by the head address register outputs, write current flows through one of the write drivers and through one of the read/write coils.
- When writing is complete, as determined in the SCU, the SCU deactivates the 'file bus' lines and 'file tag' lines, 'write gate' drops and write current stops.

Description

When the proper head is selected and the 'write gate' is established, the write drivers and the write coils are receptive to data pulses. When the 'write gate' is established, current flows through the write coil and causes all previous data to be erased even though no write data is transmitted.

Write data pulses are supplied from the SCU to the selected module write trigger. The write trigger "flips" with each pulse. The on and off outputs of the write trigger are fed to alternate level setting circuits. The 2.5V peak-to-peak outputs of one of the level-setting circuits allow the write current to flow through one half of the read/write coil to the head select circuit. When the write trigger "flips", the write driver provides a circuit to allow conduction through the other half of the read/write coil to the head select circuit (Figure 3-15).

A constant current through the write coil causes a width of 0.008" to be magnetized in a constant direction. If there are no flux changes, this width is erased. The erase coil following the write coil erases part of the write pattern to leave a band that is 0.005" wide.

Circuit Objectives

1. 'Control' tag and 'module select' line develop 'selected control' line (FD021).
2. 'File bus 0' line and 'selected control' develop 'selected write gate' (FD020).

Erase Operation

- 'Erase gate' is established concurrently with the 'write gate'.
- Write track is 0.008" wide; tunnel erase reduces track width to 0.005".

- Since the erase coil follows the write coil, the 'selected erase gate' signal continues for approximately 60 μ sec (Figure 3-14) after the 'selected write gate' signal drops.

Circuit Objectives

1. 'Control' tag and 'module select' line develop 'selected control' line (FD021).
2. 'File bus 4' line and 'selected control' develop 'selected erase gate' (FD020).

READ OPERATION

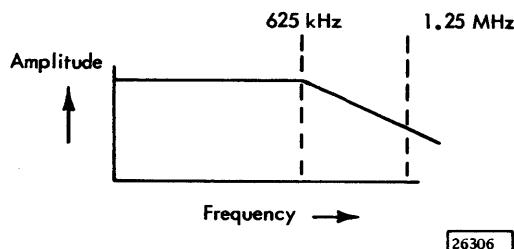
Basic Operation

- Duration of all read operations is under control of the SCU.
- When the read/write head is selected, the head output signal is fed to a preamplifier.
- As long as the module is selected and the 'selected read gate' is up, the preamplifier output is amplified and shaped and the square wave signals are returned to the SCU.
- The clock bits at the beginning of each bit cell time and the data bits are returned to the SCU.

Read Circuits

- The signal from the read/write head is approximately a sine wave. Each peak represents a bit; therefore, bit rate is twice the sine wave frequency.
- When reading clock pulses only, the signal frequency is 625 kHz. The bit rate, however, is twice the signal frequency, or 1.25 megabits/sec.
- When reading data, the signal frequency is 1.25 MHz and the bit rate is 2.5 megabits/sec.
- When the read/write head is selected, the 2 to 10 mV head output signals (5 mV average) are amplified by the preamplifier mounted near the access mechanism.
- The preamplifier has two out-of-phase inputs from the read/write heads. The two signals are amplified, and the 10-50 mV peak-to-peak outputs drive a low-pass filter which shapes the signal and removes unwanted noise pulses.

- A pulse occurs every 800 ns, or every 400 ns when data is present, causing the frequency of the read data to vary (Figure 3-12).
- The head response falls off as the signal frequency increases, approximately as shown in the following figure.



- The reduced amplitude of the preamp output at 1.25 MHz is amplified more by the differentiator circuit (Figures 3-12, 3-16) and tends to develop equal amplitude outputs for both frequencies.
- The differentiator output is overdriven and clipped in limiter circuits to provide a square wave signal (Figure 3-12, 3-16) which shifts in step with the peaks of the read head signal.
- The signal is overdriven in the amplifier, and a large signal is fed into the OR circuit. The two out-of-phase inputs to the OR are shaped and rectified. This produces a pulse (of approximately 150 ns) for each peak in the read head signal.
- The output of the OR (shaper) circuit is ANDed with 'selected read gate' and sent to the SCU through a line driver.

The differentiator circuit is used to sense the peaks of the amplifier head signals. The high frequency noise components of the preamp output must be filtered out before entering the differentiator circuit, since high frequency noise is accentuated by the differentiator circuit.

Note: Waveforms and scope patterns of the read amplifier are shown in the 2311 Maintenance Diagrams.

Circuit Objectives

1. 'Head address' register output decode selects head (FD075 and FD080).
2. 'Selected control' signal developed by 'control' tag line and 'module select' line (FD021).
3. 'Selected control' and 'file bus 1' line develop 'selected read gate' signal (FD020).
4. 'Selected read gate' signal allows amplified and shaped output to be gated to the SCU (FD085).

SAFETY CIRCUITS

- The safety circuits (FD090) check for the following:
 1. Multiple head selection.
 2. Any head selected and '[not] seek ready'.
 3. DC 'write current sense' and '[not] write gate'.
 4. 'Erase current sense' and '[not] erase gate'.
 5. 'Write gate' and '[not] ac write current' (ac write I unsafe).
 6. '[Not] seek ready' and 'write gate' or 'erase gate'.
 7. 'Read gate', and 'write gate' or 'erase gate'.
 8. 'Write gate' and '[not] erase current'.
 9. Over or under dc voltages (dc unsafe).
 10. Loss of ac power (ac unsafe).
- An unsafe condition causes module deselection and loss of the 'control' tag line. The select lock lamp will be on.
- The select lock is reset with '[not] sense speed' signal and 'heads retracted' or by the CE reset (CE 2311 file test box).

Note: Refer to "Appendix B, Special Circuits" for additional information on 'ac unsafe', 'dc unsafe', and 'ac write I unsafe'. Also refer to the FE Maintenance Manual, IBM 2311 Disk Storage Drive, Models 1, 11, and 12, Form Y26-5923, for additional information, under the heading "Select Lock Troubleshooting."

TRANSDUCERS

- Detent position, cylinder position, and index point are detected by transducers.

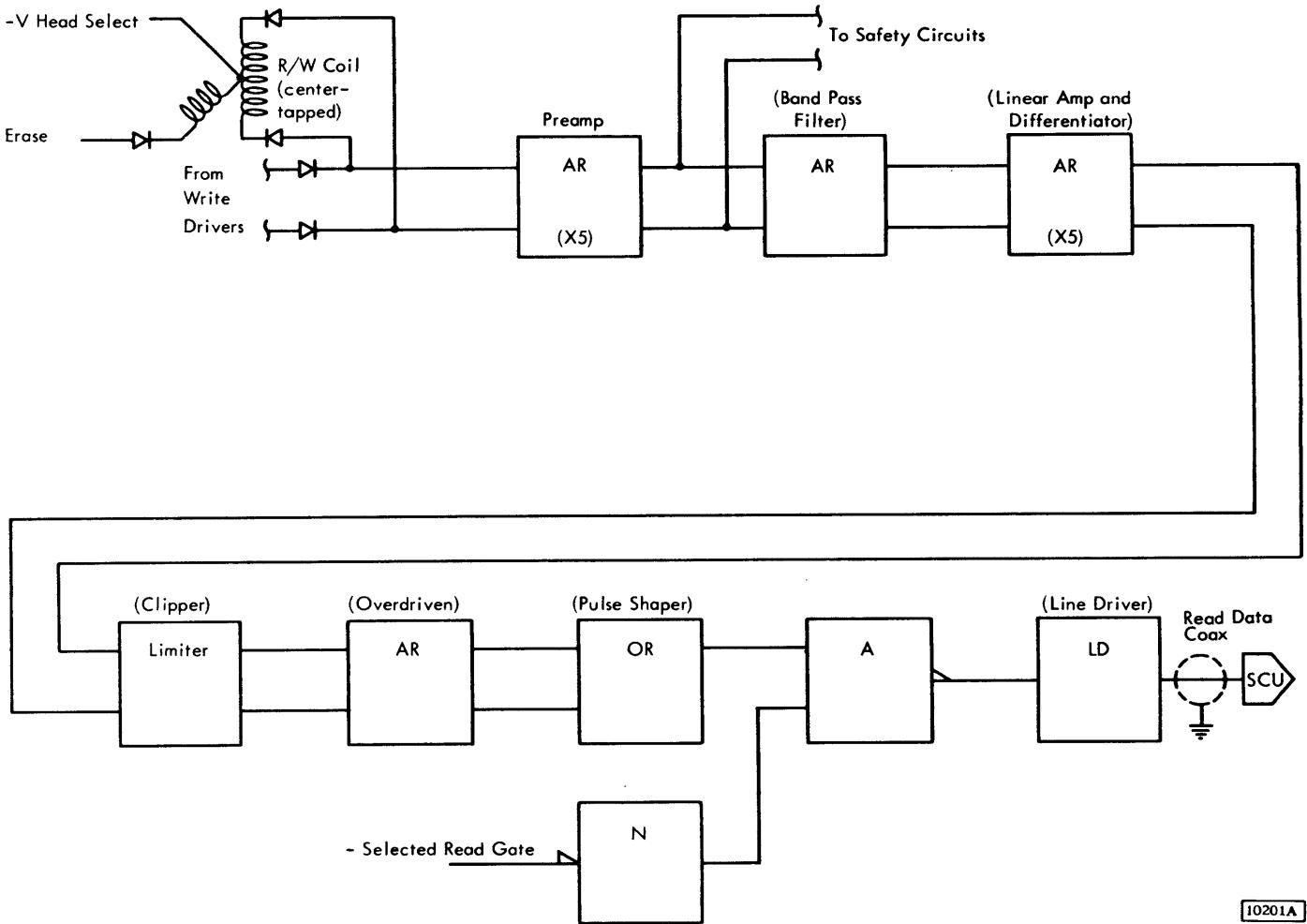
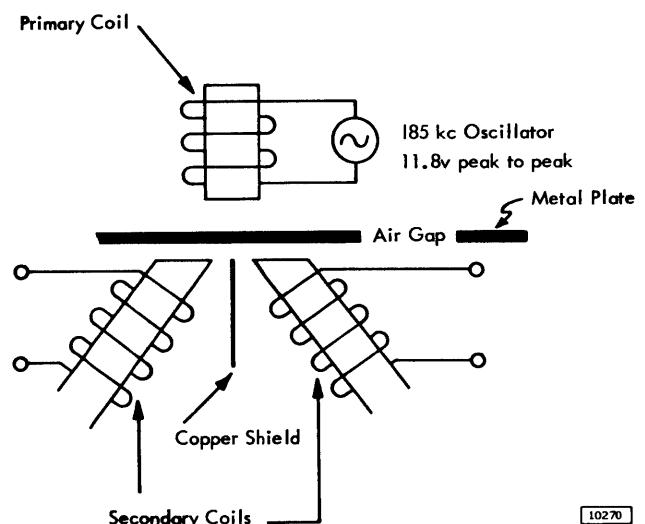
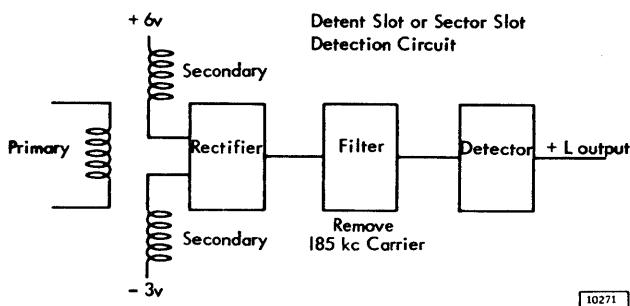


Figure 3-16. Read Circuits

- The transducer detects the presence or absence of a metal plate.
- The transducer excitation is accomplished by a 185 kHz oscillator. The excitation is required because the aluminum components cannot induce a voltage without external excitation.
- A single primary and two secondary coils are used.
- With a metal plate between primary and secondary, flux linkage is a minimum.



- With air gap between primary and secondary, the secondary output is maximum.
- Secondary output is rectified, filtered, and amplified.



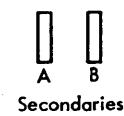
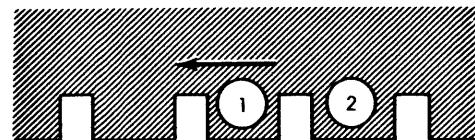
The entire transducer assembly is potted so that no adjustments are possible other than the position of the transducer assembly. Some coupling exists with the metal plate between the primary and secondary but coupling is maximum due to eddy currents when the air gap is between the coils. The two windings on the secondary coils are fed into the detection circuitry.

Detent in Detector

- The detent has an attached metal flag with a rectangular notch cut in it.
- When the detent seats in the detent wheel, the notch in the flag is located between the primary and secondaries.
- Adjustment is made by moving the transducer block to attain a specified voltage output from the detector.

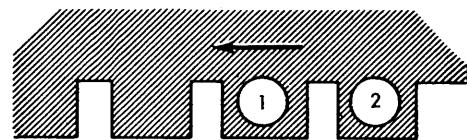
Cylinder Position Detector

- As the cylinder slotted disk passes the transducer, secondary A is located over the slot (maximum flux pattern) and secondary B is located over the land (minimum flux pattern). Output A is maximum and output B is minimum.



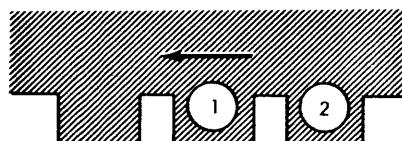
10272

- As the cylinder slotted disk moves, each secondary will be located so each is covered. Outputs are equal; a null in the output occurs.



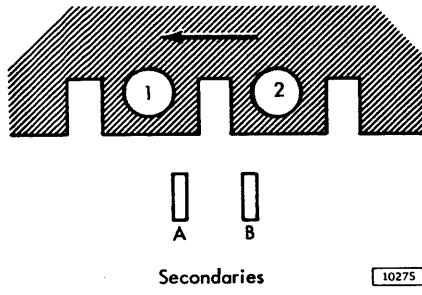
10273

- More movement causes output A to be minimum and B maximum.



10274

- Further movement results in each secondary being covered with another null output resulting.



- In summary, one maximum output occurs for each land and each slot to pass the transducer. Also, one null occurs for each land and one for each slot.
- With 102 slots in the cylinder slotted disk, 204 distinct pulses are developed to define the 203 different cylinder positions.

When the cylinder slotted disk passes through the air gap and the slot is centered in this gap, coupling into the secondaries is equal, resulting in a null in the output signal. The land between any two slots is magnetically equal to the width of the slot. When the air gap is positioned over the middle of the land, the coupling is again equal with a resulting null at the output. As the cylinder slotted disk passes from one position to another, the unbalanced coupling to the secondaries develops a signal at the transducer output as shown in Figure 3-17. The transducer output is amplified, rectified, filtered, and sensed to provide a +L cylinder pulse at the middle of each land and the middle of each slot.

Disk Speed Detection (Figure 3-18)

- The index transducer reads the slots in the sector disk. The sector disk is the bottom disk on the disk pack.
- The 'sector pulses' developed by the index transducer are used to drive the disk speed detection circuitry.

To sense 70% of rated disk speed, each 'sector pulse' resets a delay singleshot. The singleshot outputs are integrated. When the period of the 'sector pulses' is less than the period of the delay singleshot, no further output pulses result from the

singleshot. The integrator raises the level, and the relay driver causes an output of '+1 head load speed' (FD056).

Index Detection (Figure 3-19)

- The index transducer reads the slots in the sector disk. The sector disk is the bottom disk on the disk pack.
- The two slots in proximity on the sector disk are detected by the index detection circuitry.

Each 'sector pulse' fires a 750 μ sec SS. If the second 'sector pulse' follows within the 750 μ sec period, the output of the singleshot ANDs with the 'sector pulse' to provide an 'index' pulse. The 'index' pulse of the selected module is sent to the SCU (FD056).

TEN SECTOR GENERATOR (Figure 3-20)

- Ten sector generator card is used only on 2311 models 11 and 12.
- The sector card provides ten 'selected sector' pulses for use in the system/360 Model 20.

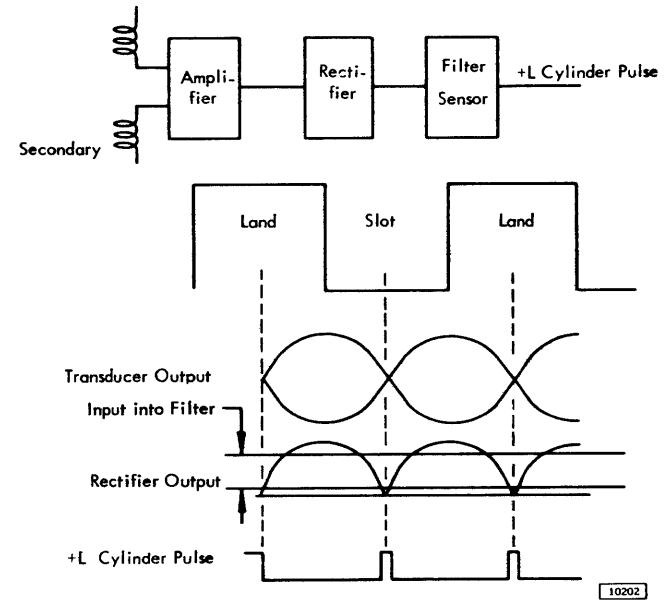


Figure 3-17. Cylinder Position Indicator

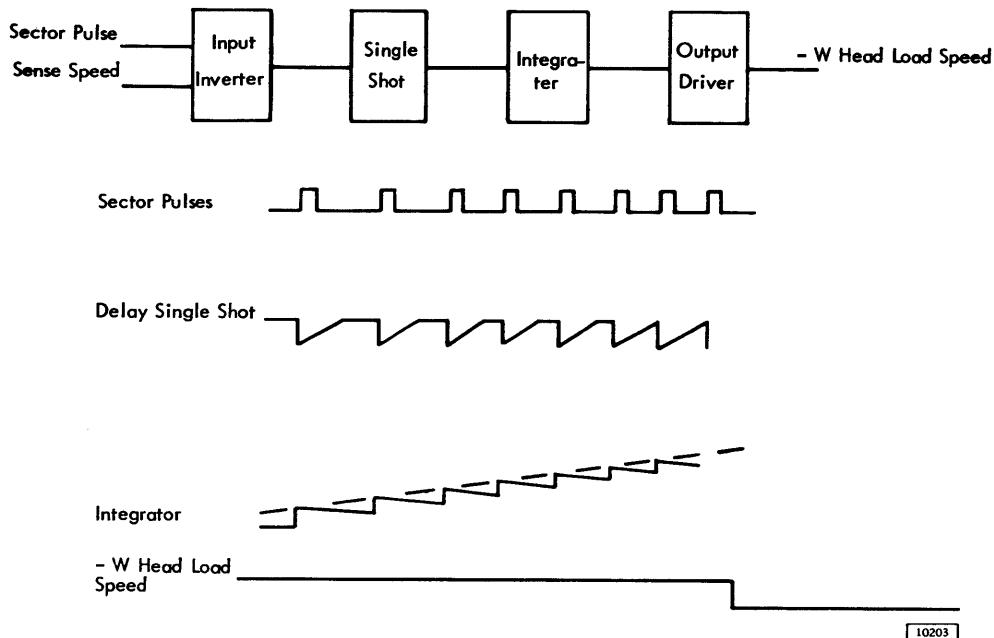


Figure 3-18. Disk Speed Detection

- The System/360 Model 20 uses the 'selected sector' pulses to control disk format.

As shown in Figure 3-19, the inputs to the ten sector generator are the same 'sector' pulses

used by the index and speed detection circuitry. The 'index' pulse and the 20 'sector' pulses are used in the ten-sector generator circuit to develop ten 'selected sector' pulses. (See timing chart, Figure 3-21.)

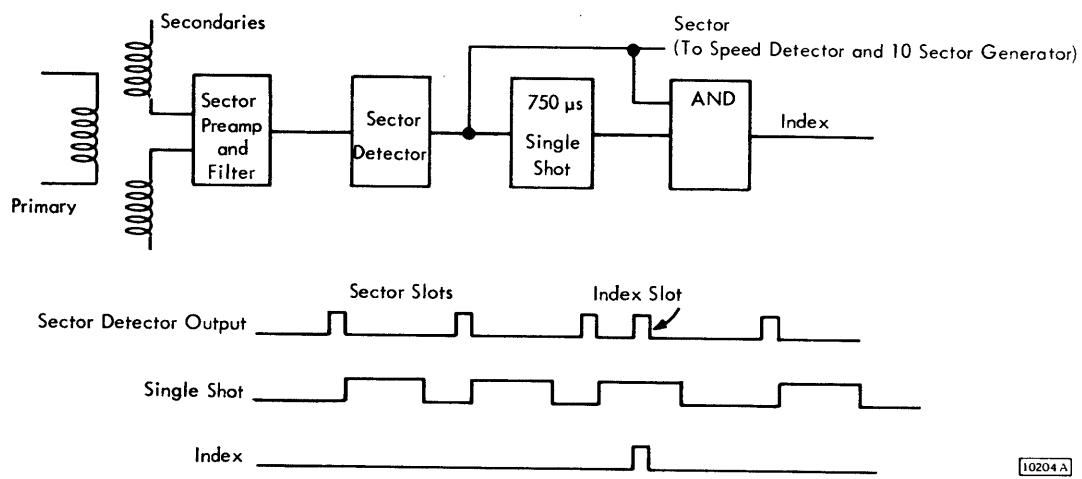
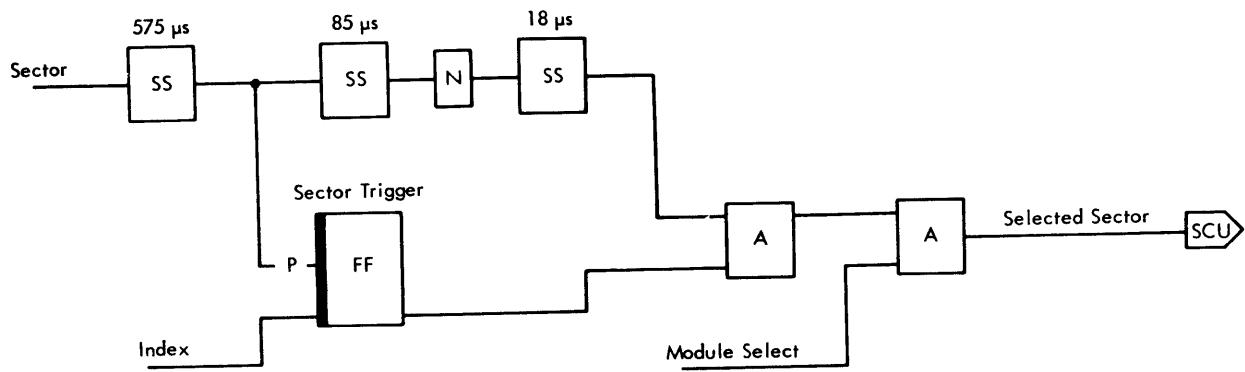


Figure 3-19. Index Detection



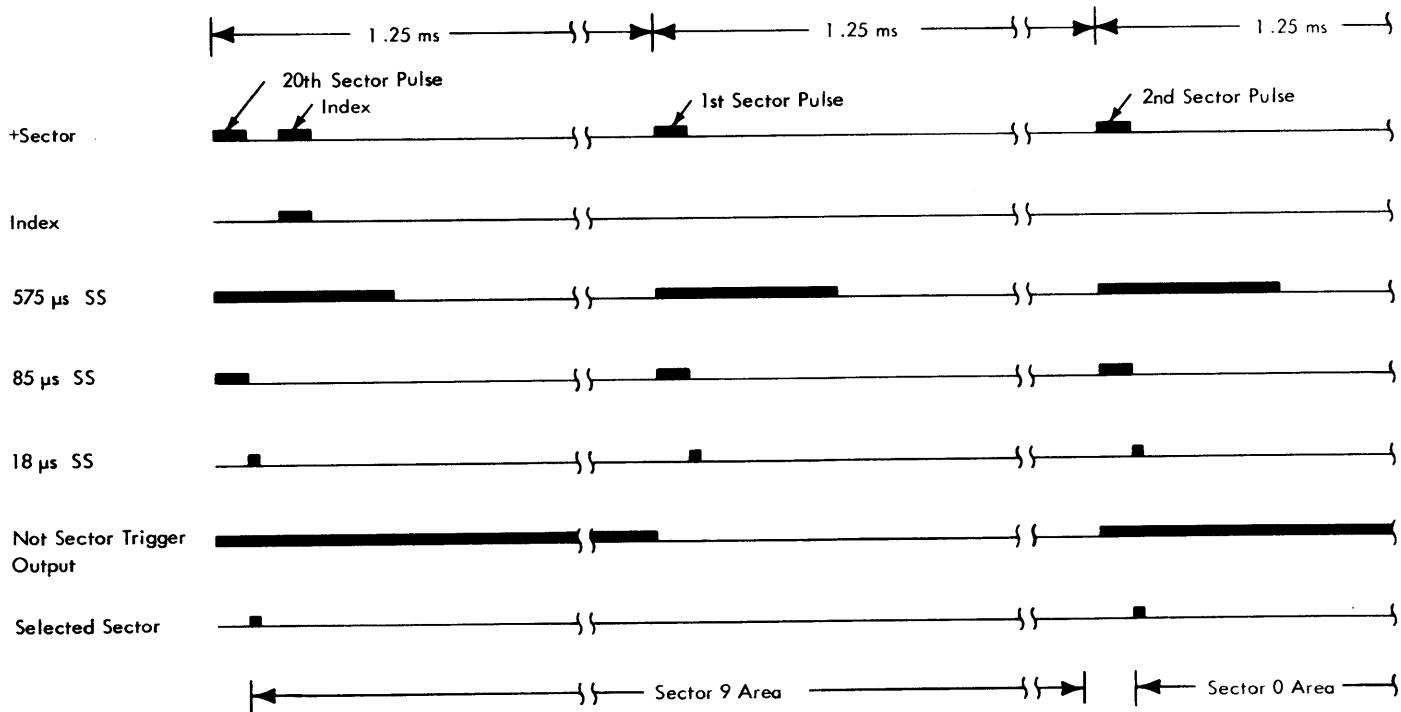
10 SECTOR GENERATOR*

FD057

* Used on 2311 Models 11 and 12

26299

Figure 3-20. 10 Sector Generator



10 Sector Generator* Timing Chart

*Used on 2311 Models 11 and 12

26300

Figure 3-21. 10 Sector Generator Timing Chart

CHAPTER 4. FEATURES

There are no features applicable to this machine.

POWER-ON SEQUENCE (Figure 5-1)

- All voltages, except +36 Vdc 8%, are developed in the SCU and are sent to the disk storage drive(s).
- When SCU dc voltages are available, +36 Vdc comes up in all files attached to the SCU.
- When all +36 Vdc supplies are up, a power-on relay is energized in the SCU.

- Relay 2 is energized in the first 2311 as a result of the power on relay coming up in the SCU.
- If the start/stop switch is in the start position, the disk pack in place, and the index block in place (cover closed), the 2311 motor starts and the 2311 is brought to operating condition.
- When the disk pack is up to 70% of speed, R2 in the next 2311 is energized.
- If the start/stop switch is in the stop position, R2 in the next 2311 is energized.

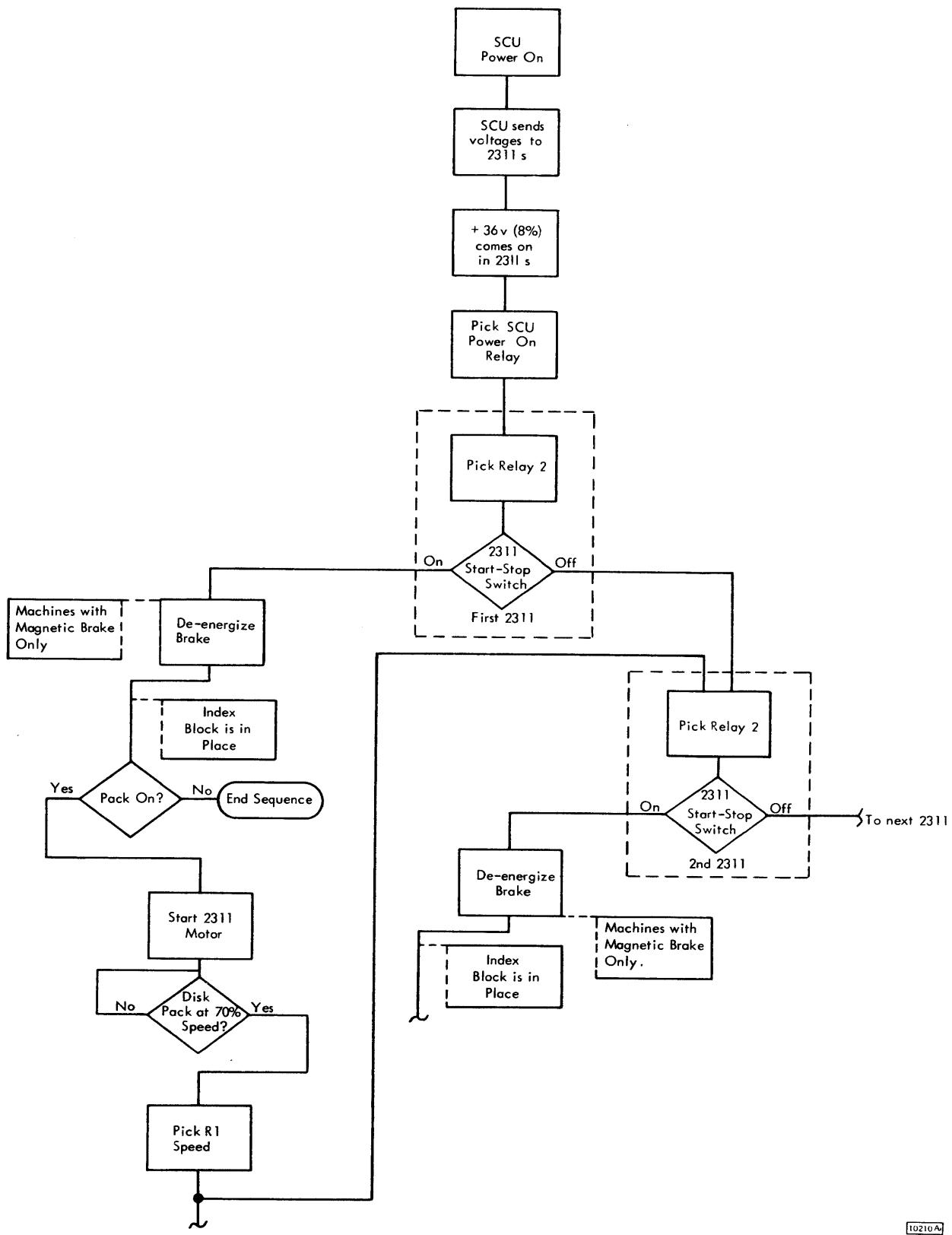


Figure 5-1. Power On Sequence

SECTION 1. CONSOLE

Operator Controls and Indicators (Figure 6-1)

Start/Stop Switch

- To make the start/stop switch operable, power must be on, pack on, and cover closed.
- With the switch in the start position, the disk drive motor is energized, the heads load and the carriage moves to cylinder 000.
- When the switch is placed in the stop position, the motor circuit is de-energized, the heads unload, and the carriage retracts.

The start/stop switch is inoperable unless all ac and dc power is on. Also the disk pack must be in place and the cover must be closed so that the index-block-in-place switch is closed.

Enable/Disable Switch

- When the CPU is stopped, this switch enables or disables the connections between the CPU and the 2311 and also controls the 2311 usage meter.
- The switch is also used to signal a 'pack change' to CPU.

If the CPU is running when the enable/disable switch setting is changed, the disk storage drive and usage meter operating status will not change until the CPU is stopped. The 2311 usage meter will stop if a select-lock occurs or the 2311 motor stops.

If the access is 'ready', turning the switch to the disable position and then to the enable position turns on the 'delta attention' latch. The 'attention' latch turns on, activating the 'gated attention' line to the 2841. 'Request in' from the 2841 comes up on the channel, and 'device end' status is presented. This 'device end' status is used by IBM operating systems.

Access Ready Lamp (Green)

- The access ready light turns on after the heads are loaded and the first seek has moved the access to cylinder 000.
- The access ready light remains on until the start/stop switch is pressed to turn off the motor or until system power is dropped.

The access ready light is also turned off if the detent remains out for more than 600 ms.

Select-Lock Lamp (Red)

- The select-lock light goes on if any of the conditions monitored by the file safety circuits are detected.
- Resetting the safety circuit and turning off the select-lock light are accomplished by turning the start/stop switch off.

SECTION 2. MAINTENANCE FEATURES

CE Controls

AC Line Switch (Sequence Panel)

- With the ac line switch off, ac power cannot be applied to the drive motor, brush motor, gate fan, and +36V power supply.

CE Top Cover Switch (Between Frame and Top Cover)

- The drive is off-line when the top cover assembly is removed unless the CE switch is manually pulled up.
- The drive is on-line whenever the top cover assembly is installed.

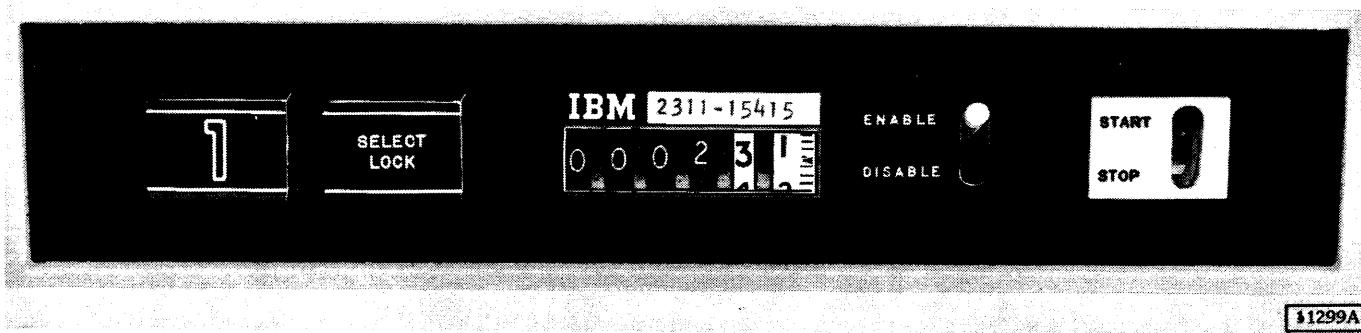


Figure 6-1. Operator Controls

APPENDIX A. MACHINE CHARACTERISTICS

<u>Characteristics</u>	<u>Description</u>	<u>Characteristics</u>	<u>Description</u>
Dimensions: Height	40"	Heat dissipation	3,340 BTU/hr
Width	30"	Mounting	Casters and standoffs
Depth	24"	Connecting cables:	One signal One ac power One dc power and data
Weight	350 lb	Disk rotational speed	2,400 ($\pm 2\%$) RPM
Primary power requirement	208 Vac, 3 phase power to each 2311	Read back data bit cell time	800 ns nominal
DC input supply voltages from SCU	-36V ($\pm 4\%$) + 6V ($\pm 4\%$) + 3V ($\pm 4\%$) - 3V ($\pm 4\%$)	Read data pulse width:	Minimum 100 n sec Nominal 150 n sec Maximum 200 n sec
Operating environment	Temperature 60°F to 90°F Humidity 8% to 80%		
Cooling	Forced room air		

AC UNSAFE

- Input: approximately 41 Vac, 60 Hz.
- Output: Safe = +3V, Unsafe = 0.0V, (<0.3V). (A1C4J11-FD090)

One-half cycle of ac is equal to approximately 8.3 ms. The time necessary to cause an unsafe condition due to missing ac is between 2.26 ms and 6.0 ms. Therefore, if between 14% and 35% of an ac cycle is missing, the circuit will be conditioned, and an 'ac unsafe' signal will be developed. The line from the 'ac unsafe' special circuit then conditions the 'file unsafe' line, which is sent to the SCU (5G-FD090). Another line developed is 'head deselect', which disables the selection circuitry of the head select card (A1J2-FD065) and prevents head selection until the unsafe condition is removed.

Although the circuitry to light the select-lock (red) is conditioned, the light will not come on because it uses +36V. The +36V comes from the transformer that is sampled by the 'ac unsafe' circuit. Therefore, if the ac fails, the +36V fails also.

Note: This circuit does not latch back. When ac is restored, the 'ac unsafe' circuit returns to normal.

DC UNSAFE

- Input: See chart.
- Output: Safe = +3V, Unsafe = 0.0V (<0.3V) (A1C4G13-FD090).

This circuit monitors all dc voltages. Should any of these voltages vary from their nominal range, the 'dc unsafe' circuit is activated. (Note 2.)

When the 'dc unsafe' circuit is activated, it conditions the 'file unsafe' line to the SCU. The 'file unsafe' line conditions the 'head deselect' line, prevents accessing, and lights the select-lock lamp (red) on the operator's console.

The circuit does not latch back. When the dc supply causing the circuit to become active returns to normal, the 'dc unsafe' circuit returns to normal.

The voltage levels at which the 'dc unsafe' circuit becomes active are shown in the chart. The circuit becomes active over a range of voltages, rather than a fixed voltage, because of manufacturing variations between SLT cards.

Voltage Monitored	Deviation Direction	Circuit becomes active between	
+ 3 Volts	+	+ 3.5	+ 4.2V
	-	+ 2.0	+ 2.3V
- 3 Volts	-	- 3.7	- 4.9V
	+	- 1.6	- 2.0V
+ 6 Volts	+	+ 6.4	+ 8.5V
	-	+ 3.6	+ 4.2V
-36 Volts	+	-25.4	-32 V
	-		Note 1

Note 1: The -36V level going more minus is not checked. The circuit only checks for the presence or absence of the voltage.

Note 2: The circuit depends on the other voltages being correct to detect one voltage that is away from its normal range. Should two or more voltages vary from their normal range at the same time, the circuit operation is unpredictable and may or may not indicate 'dc unsafe'.

AC WRITE I UNSAFE

- Input: Approximately 5 Vac peak-to-peak.
- Output: Safe = 0.0V (<0.3V), Unsafe = +3V (A1C4D04-FD090).

The input to this card comes from the read preamplifier output during writing. It is approximately 5 Vac peak-to-peak with the peaks chopped flat because of the limiting action of the read preamplifier. If this input is absent for 15 μ sec the D04 output pin (4K-FD090) goes to +3V.

This signal is ANDed with '+selected write gate' in a delaying AND that needs the presence of both '+selected write gate' and a plus output from block 4K-D04 pin for a minimum of 5.2 μ sec and a maximum of 15.5 μ sec before its output goes to 0.0V

(<0.3V). The level 0.0V at the D02 pin of 5K indicates an unsafe condition; +3V indicates a safe condition.

The output at block 5K-D02 going minus (<0.3V) sets the 'write unsafe gate' and this circuit latches back. The output of 'write unsafe gate' then conditions 'head deselect', lights the select-lock lamp (red), prevents accessing, and sends 'file unsafe' to the SCU.

To reset any select-lock condition, do one of the following: power down at the operator's panel on the 2311, push the reset button on the CE file test box if it is attached, or momentarily ground C4D13 (FD090). If these procedures do not reset

the select-lock condition, the unsafe condition still exists and should be corrected.

Do not tie C4D13 down to ground to get around a select-lock problem. A select-lock is an indication of trouble and it is designed to disable the machine until it is properly repaired, thus preventing damage to customer data.

If it is necessary to tie C4D13 (FD090) down for trouble analysis, a CE pack should first be installed and extreme care used to prevent accidental erasure of CE tracks on the pack. The jumper should definitely be removed before returning the machine to the customer.

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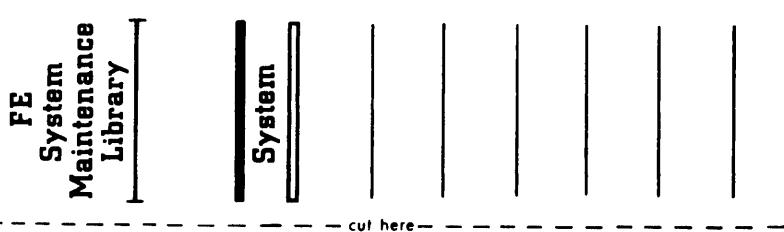
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